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# MYCOLOGIA

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# TABLE OF CONTENTS

## No. 1. JANUARY-FEBRUARY

	PAGE
The Fungous Flora of St. Croix, FRED J. SEAVER.....	1
The Mold Associated with the Ripening of Blue Veined Cheese, N. S. GOLDING.....	19
Coryneum Ruborum Oud. and its Ascogenous Stage, S. M. ZELLER.....	33
Notes and Brief Articles .....	42

## No. 2. MARCH-APRIL

Studies in Tropical Ascomycetes—III. Porto Rican Cup-Fungi, FRED J. SEAVER.....	45
Modes of Infection of Sorghums by Loose Kernel Smut, JAMES A. FARIS and GEORGE M. REED.....	51
New Species of Fungi, G. BRESADOLA.....	68
Culture Experiments with Heteroecious Rusts in 1922, 1923 and 1924, W. P. FRASER.....	78
Notes and Brief Articles.....	87

## No. 3. MAY-JUNE

✓ Zonation in Cultures of Fusarium Discolor Sulphureum, G. R. BISBY... ..	89
Botryosphaeria and Physalospora in the Eastern United States, C. L. SHEAR, NEIL E. STEVENS and MARGUERITE S. WILCOX.....	98
Mycological Notes for 1923, L. O. OVERHOLTS.....	108
The Genus Gomphidius in the United States, C. H. KAUFFMAN .....	113
Notes and Brief Articles.....	127

## No. 4. JULY-AUGUST

New or Noteworthy Porto Rican Pyrenomycetes, RAFAEL A. TORO.....	131
The Life Cycle of the Rust on Fly Poison, Chrosperma Muscaetoxicum, C. R. ORTON and FREEMAN WEISS.....	148
Relation of Glycogen to Spore-Ejection, LEVA B. WALKER and EMMA N. ANDERSEN.....	154
Club-Root of Chinese Cabbage, W. H. DAVIS.....	160
The Inheritance of Resistance of Oat Hybrids to Loose Smut, GEORGE M. REED.....	163
Notes and Brief Articles.....	182

## No. 5. SEPTEMBER-OCTOBER

The Genus Astrocystis, WILLIAM W. DIEHL.....	185
The Life History and Relationships of Diplodia Gossypina, NEIL E. STEVENS.....	191
✓ Smuts and Rusts of Utah—V, A. O. GARRETT.....	202

	PAGE
Un Nuevo Genero de las Helvellaceas, C. SPEGAZZINI.....	210
Colletotrichum v. Vermicularia, B. T. DICKSON.....	213
Preliminary Survey of Hypoxylon Poplar Canker in Oxford County, Maine, E. J. SCHREINER.....	218
Notes and Brief Articles.....	221

#### No. 6. NOVEMBER-DECEMBER

The Genus Coleosporium in the Northwestern United States, JAMES ROBERT WEIR.....	225
Notes on the Parasitic Fungi of Illinois—II, L. R. TEHON and EVA DANIELS.....	240
Five New Hypogaeous Fungi, HELEN M. GILKEY.....	250
Rusts of British Guiana and Trinidad. H. SYDOW.....	255
Notes and Brief Articles.....	263





SHORE LINE ON THE ISLAND OF ST. CROIX

# MYCOLOGIA

VOL. XVII JANUARY-FEBRUARY, 1925 No. 1

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## THE FUNGOUS FLORA OF ST. CROIX

FRED J. SEAVIR

(WITH PLATE 1)

Immediately following the week on St. Thomas, a report of which has been published,<sup>1</sup> we sailed for St. Croix spending one week also on this island, which is the largest of the three main bodies of land collectively known as the American Virgin Islands.

St. Croix is about twice the size of its neighbor St. Thomas. Unlike the latter the island is fertile and quite suitable for agriculture, although at times and in parts it is too dry for the most satisfactory results. Large quantities of cane are grown here and, in fact, one of the best varieties known is a product of St. Croix.

The surface is less hilly and automobile roads enable one to reach any part of the island without difficulty. The conditions which favor agriculture would also be favorable for mycological work, although the total number of fungi collected during the week only slightly exceeded the number taken in St. Thomas in the same length of time. On the whole, however, conditions may be said to be more conducive to mycological work than in St. Thomas.

During our sojourn in St. Croix, we made our base at Christiansted using as living quarters the old government house which was turned over to us by the courtesy of Governor Hough. The time between trips to other parts of the island was spent in the hills in the vicinity of Christiansted. One of the best collecting grounds from a mycological point of view was the valley of the

<sup>1</sup> MYCOLOGIA 16: 1-15. 1924.

[MYCOLOGIA for November (16: 255-295) was issued December 6, 1924]



Crequis river in the western part of the island, although little time was spent there.

On March 23, we covered Eagle Mountain, the highest elevation in the island, ascending one slope and descending more abruptly on the opposite side. This also proved to be a fruitful excursion. The view from this elevation was very inspiring, commanding as it did the greater part of the island.

On March 25, just before sailing for Porto Rico, a short tramp was made into the suburbs of Christiansted and resulted in the finding of the spongy polypore, *Tomophagus Colossus*, a very rare fungus as noted in the following list. As in the St. Thomas list, the species below in full face type are those collected for the first time while the starred (\*) species are those previously collected and recollected by us.

In addition to the literature cited in the "Fungous Flora of St. Thomas," Millspaugh's Flora of St. Croix<sup>2</sup> contains a number of additional species of fungi.

### CHYTRIDIALES

**Synchytrium decipiens** Farlow, Bot. Gaz. 10: 240. 1885.

On *Dolicholus* sp. collected on Mt. Eagle.

The fungus appears on both leaves and stems forming conspicuous gall-like growths on the latter.

### MUCORALES

**Pilobolus crystallinus** (Wigg.) Tode, Fungi Meckl. 1: 41. 1790.

*Hydrogerea crystallina* Wigg. Fl. Holsat. 110. 1780

Collected on dung.

### PERONOSPORALES

**Albugo Bliti** (Biv.) Kunze, Rev. Gen. Pl. 2: 658. 1891.

*Uredo Bliti* Biv. Stirp. Rar. Silicia 3: 658. 1891.

On *Amaranthus tristis* L.

**ALBUGO IPOMOEAE-PANDURANAE** (Schw.) Swing. Jour. Myc. 7: 112. 1892.

<sup>2</sup> Field Mus. Nat. Hist. Publ. Bot. 1: 465-467. 1902.

*Accidium Ipomoeae-panduranae* Schw. Schr. Nat. Ges. Leipzig  
1: 69. 1822.

Reported by Ferdinandsen & Winge on *Ipomoea Pcs-caprae* L.  
*Albugo Tragopogonis* (DC.) S. F. Gray is reported by Mills-  
paugh on the same host and is probably identical with the above.

**Peronoplasmopara cubensis** (Berk. & Curt.) Clint. Rep. Conn.  
Agr. Exp. Station 1904: 335. 1905.

*Peronospora cubensis* Berk. & Curt. Jour. Linn. Soc. 10: 363.  
1868.

Collected on *Cucumis Anguria* L.

### PERISPORIALES

**ASTERINA COCCOLOBAE** Ferd. & Winge, Bot. Tidssk. 29: 10.  
1908.

Described from material collected in St. Croix by Raunkiaer on  
*Coccolobis Uvifera* (L.) Jacq.

**ASTERINA COLUBRINAE** Ellis & Kels. Bull. Torrey Club 24: 207.  
1897.

Reported on *Colubrina reclinata* (L'Hér.) Brongn. by Mills-  
paugh.

**ERYSIPHE COMMUNIS** (Wallr.) Fries, Summa Veg. Scand. 406.  
1849.

*Alphitomorpha communis* Wallr. Fl. Crypt. Germ. 2: 758.  
1833.

Reported by Ferdinandsen & Winge on *Sida* sp. So far as we  
are aware, the perfect stage of this species has not been found in  
the West Indies so that the identity of the species is somewhat in  
doubt.

**Parodiella grammodes** (Kunze) Cooke, Grevillea 13: 106. 1884.  
*Sphacria grammodes* Kunze, Berk. Jour. Linn. Soc. 10: 390.  
1868.

Collected on *Crotalaria retusa* L.

### PHACIDIALES

**Tryblidium rufulum** (Spreng.) Ellis & Ev. N. Am. Pyrenom. 690.  
1892.

*Hysterium rufulum* Spreng. Vet. Akad. Handl. 1820: 50. 1820.  
Collected commonly on dead sticks.

### PEZIZALES

*LACHNEA SCUTELLATA* (L.) Gill. Champ. Fr. Discom. 75. 1879.  
*Peziza scutellata* L. Sp. Pl. 1181. 1753.  
Reported by Ferdinandsen & Winge.

*Patellaria atrata* (Hedw.) Fries, Syst. Orbis Veg. 114. 1825.  
*Lichen atratus* Hedw. Laub-Moose 2: 73. 1788.  
Collected on coconut petioles.

*Pyronema omphalodes* (Bull.) Fuckel, Symb. Myc. 319. 1869.  
*Peziza omphalodes* Bull. Herb. Fr. pl. 485. f. 1. 1790— Hist.  
Champ. 264. 1791.  
Collected on burnt ground.

### HYSTERIALES

*Glonium clavisorum* sp. nov.

Apothecia gregarious, rather prominent, parallel, straight or slightly curved, the lips tightly closed, black, striately marked, reaching a length of two or three mm.; asci clavate, 8-spored, in mass yellowish or yellowish-green, reaching a length of 100–120  $\mu$  and a diameter of 10–12  $\mu$ ; spores 1-seriate with the ends strongly overlapping, clavate-fusoid, 1-septate, constricted at the septum, hyaline, reaching a length of 20  $\mu$  (or rarely 22  $\mu$ ) and a diameter of 6–7  $\mu$ .

On decorticated wood.

This species was first collected in Nicaragua by C. L. Smith and labeled, apparently by Mr. Ellis, *Glonium simulans* Ger. f. *macrospora*. So far as the writer can discover, this name has never been published. The name proposed by Ellis is untenable as a specific name since it has been applied to a very different species from Mississippi by Tracy and Earle. A sterile specimen of what appears to be the same plant was collected in Porto Rico by Underwood and Griggs. Our specimen for which the above name had already been suggested agrees well with specimens collected in Nicaragua for which Mr. Ellis suggested the name "macrospora." Since that name is untenable we publish our own.

## HYPOCREALES

**CREONECTRIA OCHROLEUCA** (Schw.) Seaver, *Mycologia* 1: 190. 1909.

*Sphaeria ochroleuca* Schw. Trans. Am. Phil. Soc. II. 4: 204. 1832.

Reported by Ferdinandsen & Winge under the name of *Nectria vulgaris* Speg., which is regarded as a synonym of the above.

**HYPOCREA RUFA** (Pers.) Fries, *Summa Veg. Scand.* 383. 1849.

*Sphaeria rufa* Pers. Obs. Myc. 1: 20. 1796.

Reported by Børghesen & Paulsen.

**LISEA AUSTRALIS** Speg. Anal. Soc. Ci. Argent. 12: —76. 1881.

Reported by Børghesen & Paulsen.

**Nectria episphaeria** (Tode) Fries, *Summa Veg. Scand.* 388. 1849.

*Sphaeria episphaeria* Tode, *Fungi Meckl.* 2: 21. 1791.

Collected on the remains of old sphaeriaceous fungi.

## FIMETARIALES

**Fimetaria fimicola** (Roberge) Griffiths & Seaver, *N. Am. Fl.* 3: 66. 1910.

*Sphaeria fimicola* Roberge; Desmaz. Ann. Sci. Nat. III. 11: 353. 1849.

Collected on dung.

## PHYLLACHORALES

**Phyllachora biareolata** Speg. An. Soc. Ci. Arg. 26: 36. 1888.

On *Eugenia rhombica* (Berg.) Krug & Urban.

This was at first referred to *Phyllachora Hetszelii* Chardon but on comparison with authentic material was found to differ from that species in the much larger stromata as well as in spore sizes. It seems to agree with the above named species from South America so far as we can judge, although no authentic material has been seen.

**Phyllachora Crotonis** (Cooke) Sacc. Syll. Fung. 2: 599. 1883.

*Dothidea Crotonis* Cooke, *Grevillea* 10: 129. 1882.

Collected on the leaves of *Croton* sp.

**Phyllachora graminis** (Pers.) Fuckel, Symb. Myc. 216. 1869.

*Sphacria graminis* Pers. Obs. Myc. 1: 18. 1796.

Reported by Millspaugh from St. Croix.

**Phyllachora sphaerosperma** Winter, Hedwigia 23: 170. 1884.

Collected on *Cenchrus* ? (host without fruit).

**Phyllachora Rickseckeri** Ellis & Kels. (in herb.) sp. nov.

Stromata 150–170  $\mu$ , pierced above; asci clavate, 40–50 x 12–15  $\mu$ , short-stipitate, 8-spored, aparaphysate; sporidia crowded, fusoid, deep reddish-brown in the mass, pale brownish when seen singly, 4–5-nucleate, 20–26 x 4–5  $\mu$ .

On *Cissampelos Parcira* L. Signal Hill, St. Croix, Feb. 10, 1896.

While the spores are described as colored they appear practically hyaline or at most faintly yellowish. Listed by Millspaugh as *Guignardia* sp.

## SPHAERIALES

**Daldinia concentrica** (Bolt.) Ces. & DeNot. Comm. Critt. Ital. 1: 198. 1863.

*Sphacria concentrica* Bolton, Fungi Halifax 3: 180. 1789.

Collected on old wood.

**DALDINIA ESCHSCHOLZII** (Ehrenb.) Rehm, Ann. Myc. 2: 175. 1905.

*Sphacria Eschscholzii* Ehrenb. Horae Physicae 89. 1820.

Reported by Ferdinandsen & Winge. A large plant, possibly only a form of the preceding.

**GUIGNARDIA PIPERICOLA** Stevens, Trans. Ill. Acad. Sci. 10: 183. 1917.

Collected on *Piper Amalago* L. Probably *Physalospora* sp. reported by Millspaugh on *Piper Sieberi* DC. is the same as the above, although no specimen is available for confirmation of this suspicion.

\* **HYPOSPILA CORDIANA** Ellis & Kels. Bull. Torrey Club 24: 208. 1897.

*Trabutiella Cordiae* Stevens, Bot. Gaz. 70: 401. 1920.

Collected on *Cordia alliodora* L. Comparison with authentic material shows the above species described by Stevens to be identical with that of Ellis and Kelsey. Stevens (l.c.) established the genus *Trabutella* for this species. The name is untenable, having been previously used by Theissen & Sydow for an entirely different plant (Ann. Myc. 13: 359).

**Hypoxyton annulatum** (Schw.) Mont. in Hist. Chil. 7: 445. 1854.

*Sphaeria annulata* Schw. Jour. Acad. Sci. Phila. 5: 16. 1825.

Collected commonly on old wood.

**Hypoxyton effusum** Nits. Pyrenom. Ger. 48. 1867.

Specimens collected on old wood appear to conform well with the description of the above species.

**Hypoxyton fusco-purpureum** (Schw.) Berk. Jour. Linn. Soc. 10: 385. 1869.

*Sphaeria fusco-purpurea* Schw. Jour. Acad. Sci. Phila. 5: 16. 1825.

Collected on old wood.

**Hypoxyton fuscum** (Pers.) Fries, Summa Veg. Scand. 384. 1849.

*Sphaeria fusca* Pers. Syn. Fung. 12. 1801.

Collected on the bark of tree.

**Hypoxyton jecorinum** Berk. & Rav.; Berk. Grevillea 4: 50. 1875.

Collected on old wood.

**HYPOXYLON PSEUDOPACHYLOMA** Speg. Bol. Acad. Ci. Cordoba 11: 206. 1887.

Reported by Ferdinandsen & Winge for St. Croix.

**HYPOXYLON RUBIGINOSUM** (Pers.) Fries, Summa Veg. Scand. 384. 1849.

*Sphaeria rubiginosa* Pers. Syn. Fung. 11. 1801.

Reported from St. Croix by Ferdinandsen & Winge.

**NUMMULARIA DURA** Ferd. & Winge, Bot. Tidssk. 29: 15. 1908.

Reported by Ferdinandsen & Winge on dead branches.

**NUMMULARIA REPANDA** (Fries) Nitsch. Pyrenom. Ger. 57. 1867.

*Sphaeria repanda* Fries, Obs. Myc. 1: 168. 1815.

Collected commonly on dead branches.

**Nummularia tinctor** (Berk.) Ellis & Ev. N. Am. Pyrenom. 627. 1892.

*Sphaeria tinctor* Berk. in Hooker, Jour. Bot. 4: 311. 1845.

Collected on old wood.

**Physalospora Andirae** Stevens, Trans. Ill. Acad. Sci. 10: 184. 1917.

Collected on leaves of *Andira inermis* H.B.K. [*Andira jamaicensis* (W. Wr.) Urb.].

**Poronia Oedipus** Mont. Syll. Fung. 209. 1856.

Collected commonly on manure.

**Rosellinia aquila** (Fries) DeNot. Atti. Sci. Ital. 6: 485. 1845.

*Sphaeria aquila* Fries, Syst. Myc. 2: 442. 1822.

Collected on old wood.

**Rosellinia Bresadolae** Theiss. Ann. Myc. 6: 351. 1908.

Collected on old wood.

**ROSELLINIA METACHIROA** Ferd. & Winge, Bot. Tidssk. 29: 16. 1908.

Reported by Ferdinandsen & Winge on old wood.

**ROSELLINIA ST. CRUCIANA** Ferd. & Winge, Bot. Tidssk. 29: 16. 1908.

Described from material collected in St. Croix on petioles of *Cocos nucifera* L.

**Rosellinia subiculata** (Schw.) Sacc. Syll. Fung. 1: 255. 1882.

*Sphaeria subiculata* Schw. Schr. Nat. Ges. Leipzig 1: 44. 1822.

Collected on old wood.

**SPIROGRAMMA BOERGESENII** Ferd. & Winge, Vidensk. Meddel. 1908: 143.

The genus and species are based on material collected in St. Croix and St. Jan.

**Valsa chlorina** Pat. Bull. Soc. Myc. Fr 22: 56. 1906.

?*Eutypella Cocos* Ferd. & Winge, Vidensk. Meddel 1908: 141.  
1908.

On old coconut husks.

**XYLARIA APPENDICULATA** Ferd. & Winge, Bot. Tidssk. 29: 17.  
1908.

Reported by Ferdinandsen & Winge on dried leaves of *Crescentia cucurbitina* L.

**Xylaria apiculata** Cooke, Grevillea 8: 66. 1879.

Collected on old wood.

**XYLARIA LIGNOSA** Ferd. & Winge, Bot. Tidssk. 29: 18. 1908.

Described from material collected in St. Croix.

## PHYLLOSTICTALES

**CICINNOBOLUS** sp.

Reported by Ferdinandsen & Winge on *Crotalaria retusa* L. and *Priva lappulacea* (L.) Pers.

**DARLUCA FILUM** (Biv.) Sacc. Syll. Fung. 3: 410. 1884.

*Sphaeria Filum* Biv.-Bern. Stirp. Rar. Manip. 3: 12. 1815.

Reported by Ferdinandsen & Winge on *Puccinia Synedrellae* P. Henn.

**Phoma lathyrina** Sacc. Michelia 2: 274. 1881.

Collected on pods of *Albizzia Lebbeck* (L.) Benth.

**Phyllosticta Pithecolobii** Young, Mycologia 7: 145. 1915.

Collected on *Pithecolobium Unguis-cati* (L.) Benth.

## HYPHOMYCETES

**CHROMOSPORIUM PACHYDERMA** Ferd. & Winge, Bot. Tidssk. 29: 22. 1908.

Described from material collected in St. Croix, on rotten wood.

**FUMAGO VAGANS** Pers. Myc. Eu. 1: 9. 1822.

Reported by Ferdinandsen & Winge on *Wedelia buphthalmoides* Griseb.; also collected on the leaves of some undetermined host.



OIDIUM CYPARISSIAE Syd. Hedwigia 36: (163). 1897.

Reported by Ferdinandsen & Winge on *Euphorbia pilulifera* L.; also an unnamed species of *Oidium* has been reported on various hosts.

**Oidium erysiphoides** Fries, Syst. Myc. 3: 432. 1829.

Collected on living leaves of cultivated peppers.

PERICONIA ATRA Corda, Ic. Fung. 1: 19. 1837.

Reported by Ferdinandsen & Winge on *Saccharum officinarum* L.

TRICHODERMA LIGNORUM (Tode) Harz. Bull. Soc. Imp. Mosc. 44: 116. 1871.

*Pyrenium lignorum* Tode, Fungi Meckl. 1: 33. 1790.

Reported by Ferdinandsen & Winge.

## UREDINALES

COLEOSPORIUM ELEPHANTOPODIS (Schw.) Thüm. Myc. Univ. 953. 1878.

*Uredo Elephantopodis* Schw. Schr. Nat. Ges. Leipzig 1: 70. 1822.

Reported by Ferdinandsen & Winge on *Elephantopus mollis* Kth. under the name of *Colcosporium Sonchi* Schw.

COLEOSPORIUM IPOMOEAE (Schw.) Bur. Bull. Ill. Lab. Nat. Hist. 2: 217. 1885.

*Uredo Ipomoeae* Schw. Schr. Nat. Ges. Leipzig 1: 70. 1822.

Reported by Millspaugh on *Ipomoea coccinea* L.; also collected by Dr. J. N. Rose on *Ipomoea Nil* (L.) Roth.

ENDOPHYLLUM CIRCUMSCRIPTUM (Schw.) Whetzel & Olive, Am. Jour. Bot. 4: 49. 1917.

*Aecidium circumscriptum* Schw.; Berk. & Curt. Jour. Phila. Acad. Sci. 2: 283. 1853.

*Aecidium Cissi* Winter, Hedwigia 23: 168. 1884.

Reported on *Cissus sicyoides* L.

\* PROSPIDIUM APPENDICULATUM (Wint.) Arth. Jour. Myc. 13: 31. 1907.

*Puccinia appendiculata* Winter, Flora 67: 262. 1884.

Collected on *Tecoma Stans* (L.) Juss.

PUCCINIA ARECHAVALETAE Speg. Anal. Soc. Ci. Argent. 12: 67. 1881.

Reported by Ferdinandsen & Winge on *Cardiospermum microcarpum* H.B.K.

**Puccinia Blechi** Lagerh. Bull. Soc. Myc. Fr. 11: 214. 1895.

Collected on *Blechnum Blechnum* (L.) Millsp.

PUCCINIA CENCHRI Dietl. & Holw.; Holway, Bot. Gaz. 24: 28. 1897.

Collected on *Cenchrus* sp.

PUCCINIA CRASSIPES Berk. & Curt.; Berk. Grevillea 3: 54. 1874.

Reported by Ferdinandsen & Winge on *Ipomoea triloba* L. and *Quamoclit coccinea* (L.) Moench. under the name of *Puccinia Ipomoeae-panduranac*. Also reported by Millsbaugh under the name of *Puccinia opulenta* Speg.

\* PUCCINIA EMILIAE P. Henn. Hedwigia 37: 278. 1898.

Reported by Ferdinandsen & Winge on *Emilia sagittifolia* [sagittata DC.] and *Emilia sonchifolia* (L.) DC. Also collected on *Emilia* sp.

PUCCINIA HETEROSPORA Berk. & Curt. Jour. Linn. Soc. 10: 356. 1868.

*Uromyces Sidae* Thüm. Rev. Myc. 1: 10. 1879.

Reported on *Abutilon periplocifolium* Sw.; *Metastelma Schlechtendalii* Dec.; and *Sida supina glabra*.

**Puccinia Huberi** P. Henn. Hedwigia Beibl. 39: 76. 1900.

Collected on *Panicum adpersum* Trin.

\* PUCCINIA IMPEDITA Mains & Holw.; Arth. Mycologia 10: 135. 1918.

Collected on *Salvia occidentalis* Sw. Also reported by Ferdinandsen & Winge under the name of *Puccinia Menthae* Pers.

PUCCINIA INFLATA Arth. Bull. Torrey Club 33: 516. 1906.

Reported by Ferdinandsen & Winge on *Stigmatophyllum periplocifolium* A. Juss. under the name of *Puccinia insueta* Wint.

PUCCINIA INSULANA (Arth.) Jackson, Bot. Gaz. 65: 296. 1918.  
*Argomyces insulanus* Arth. Mycologia 7: 179. 1915.

Reported on *Vernonia* sp. under the name of *Puccinia Vernoniae* Cooke. Also collected on *Vernonia albicaulis* Pers.

PUCCINIA INVAGINATA Mains & Holw.; Arth. Mycologia 10: 135. 1918.

*Uredo Gouaniae* Ellis & Kelsey, Bull. Torrey Club 24: 209. 1897.

Collected on *Gouania polygama* (Jacq.) Urban.

**Puccinia Leonotidis** (P. Henn.) Arth. Mycologia 7: 245. 1915.

*Uredo Leonotidis* P. Henn. in Engler, Pfl. Ost.-Afr. C: 52. 1895.

Collected on *Leonotis nepetaefolia* (L.) R. Br.

**Puccinia levis** (Sacc. & Bizz.) Magnus, Ber. Deuts. Bot. Ges. 9: 190. 1891.

*Diorchidium leve* Sacc. & Bizz.; Sacc. Michelia 2: 648. 1882.

Collected on *Paspalum fimbriatum* H.B.K.

PUCCINIA MACROPODA Speg. Anal. Soc. Ci. Argent. 10: 13. 1880.

Reported by Ferdinandsen & Winge on *Iresine elatior* L.

PUCCINIA OBLIQUA Berk. & Curt.; Berk. Jour. Linn. Soc. 10: 356. 1858.

Collected on *Metastelma Schlechtendalii* Dec. by Dr. J. N. Rose. Also collected by A. E. Ricksecker.

PUCCINIA SPERMACOCES Berk. & Curt. Grevillea 3: 53. 1874.

Reported by Millsbaugh on *Spermacoce* sp.; *Borreria parviflora* G. F. W. Meyer.

\* PUCCINIA SYNEDRELLAE P. Henn. Hedwigia 37: 277. 1898.

On *Synedrella nodiflora* (L.) Gaertn.

**Puccinia Urbaniana** P. Henn. Hedwigia 37: 278. 1898.

Collected on *Valerianodes*.

PUCCINIOSIRA PALLIDULA (Speg.) Lagerh. Tromsø Mus. Aarsh. 16: 122. 1894.

*Aecidiella Triunfettiae* Ellis & Kelsey, Bull. Torrey Club 24: 208. 1897.

Reported by Ferdinandsen & Winge on *Triumfetta* sp.

**Uredo Erythroxylois** Graz. Bull. Soc. Myc. Fr. 7: 153. 1891.  
Collected on *Erythroxylois* sp.

\* **UREDIO JATROPHICOLA** Arth. Mycologia 7: 331. 1915.  
Collected on *Jatropha gossypifolia* L. Also collected by Dr. J. N. Rose.

**Uromyces Anthacanthi** H. S. Jackson, Mycologia 16: 47. 1923.  
Collected on *Anthacanthus spinosus* (Jacq.) Nees.  
The species was described from material collected in St. Croix.

\* **UROMYCES COMMELINAE** Cooke, Trans. Roy. Soc. Edinb. 31: 342. 1888.

*Uredo Commelinaceae* Ellis & Kelsey, Bull. Torrey Bot. Club 24: 209. 1897.

On *Commelina elegans* H.B.K.

**Uromyces Dolicholi** Arth. Bull. Torrey Club 33: 27. 1906.  
On *Dolicholus* sp.; *Cajan Cajan* (L.) Millsp.

**UROMYCES EUPHORBIAE** Cooke & Peck; Peck, Ann. Rep. N. Y. State Mus. 25: 90. 1873.

Reported by Ferdinandsen & Winge on *Euphorbia prostrata* Ait.

**UROMYCES GEMMATUS** Berk. & Curt.; Berk. Jour. Linn. Soc. 10: 357. 1869.

Reported by Millspaugh on *Convolvulus nodiflorus* Desr. under the name of *Puccinia Convolvuli* (Pers.) Cast.

**Uromyces leptodermus** Syd.; Syd. & Butler, Ann. Myc. 4: 430. 1906.

Collected on *Panicum barbinode* Trin.

## USTILAGINALES

**USTILAGO ZEAЕ** (Beckm.) Unger, Einfl. Bodens 211. 1836.  
*Lycoperdon Zeae* Beckm. Hannov. Mag. 6: 1330. 1768.

Reported by Ferdinandsen & Winge on *Zea Mays* L.

**MYKOSYRINX CISSI** (DC.) G. Beck, Ann. Nat. Hofmus. Wien **9**: 123. 1894.

*Uredo Cissi* DC. in Poir. Encycl. Meth. Bot. **8**: 228. 1808.

Reported by Børghesen & Paulsen on *Cissus* sp.

## AGARICALES

**Amauroderma flaviporum** Murrill, N. Am. Fl. **9**: 116. 1908.

Collected on old wood.

**Campanularius solidipes** (Peck) Murrill, Mycologia **10**: 31. 1918.

*Agaricus solidipes* Peck, Ann. Rep. N. Y. State Cab. **23**: 101. 1872.

Collected on dung.

**CORIOLUS NIGROMARGINATUS** (Schw.) Murrill, Bull. Torrey Club **32**: 649. 1906.

*Boletus nigromarginatus* Schw. Schr. Nat. Ges. Leipzig **1**: 98. 1822.

Reported by Børghesen & Paulsen under the name of *Polyporus hirsutus* Fries which is regarded by Murrill as a synonym of the above.

**Coriolopsis fulvocinerea** Murrill, N. Am. Fl. **9**: 76. 1908.

Collected on dead wood.

**Coriolopsis occidentalis** (Klotzsch) Murrill, Bull. Torrey Club **32**: 358. 1905.

*Polyporus occidentalis* Klotzsch, Linnaea **8**: 486. 1833.

Collected on old wood.

**Coriolopsis rigida** (Berk. & Mont.) Murrill, N. Am. Fl. **9**: 75. 1908.

*Trametes rigida* Berk. & Mont. Ann. Sci. Nat. III. **11**: 240. 1849.

Collected on dead wood.

**Coriolus pinsitus** (Fries) Pat. Tax. Hymén. 94. 1900.

*Polyporus pinsitus* Fries, Elench. Fung. 95. 1828.

Collected on old wood.

**COPRINUS PLICATILIS** Fries, *Epicr. Myc.* 252. 1836.

Reported from St. Croix by Fries.

▷ **DAEDALEA AMANITOIDES** Beav. *Fl. Oware* 1: 44. 1805.

Collected on old wood. Also reported by Børgesen & Paulsen under the name of *Trametes elegans* (Spr.) Fries, which is now regarded as a synonym of the above.

\* **ELFVINGIELLA FASCIATA** (Sw.) Murrill, *Trop. Poly.* 90. 1915.

*Boletus fasciatus* Sw. *Prodr.* 149. 1788.

Collected on old wood. Also reported by Børgesen & Paulsen under the name of *Polyporus fomentarius* (L.) Fries.

**FLAMMULA PEREGRINA** (Fries) Sacc. *Syll. Fung.* 5: 814. 1887.

*Agaricus peregrinus* Fries, *Elench. Fung.* 1: 31. 1827.

Reported from St. Croix by Fries on wood.

**Ganoderma subincrustatum** Murrill, *N. Am. Fl.* 9: 122. 1908.

Collected on old wood.

**Gloeophyllum striatum** (Sw.) Murrill, *Bull. Torrey Club* 32: 370. 1905.

*Agaricus striatus* Sw. *Prodr.* 148. 1788.

Collected on old wood.

**Hapalopilus lichnoides** (Mont.) Murrill, *Bull. Torrey Club* 31: 417. 1904.

*Polyporus lichnoides* Mont. *Pl. Cell. Cuba* 401. 1842.

Collected on old wood.

**HIATULA DISCRETA** (Fries) Sacc. *Syll. Fung.* 5: 307. 1887.

*Agaricus discretus* Fries, *Elench. Fung.* 1: 20. 1827.

Reported from St. Croix by Fries.

**Lentinus hirtus** (Fries) Murrill, *Mycologia* 3: 29. 1911.

*Agaricus hirtus* Fries, *Linnaea* 5: 508. 1830.

Collected on old wood.

**MARASMIUS ARECARIUS** Fries, *Epicr. Myc.* 380. 1836.

Reported from St. Croix by Fries.

**NAUCORIA PEDIADDES** (Fries) Sacc. Syll. Fung. 5: 844. 1887.

*Agaricus pediades* Fries, Syst. Myc. 1: 290. 1821.

Reported from St. Croix by Fries.

**PANUS XYLOPODIUS** (Lév.) Fries, Nov. Acta. Soc. Sci. Upsal. III. 1: 40. 1855.

*Lentinus xylopodius* Lév. Ann. Sci. Nat. III. 5: 119. 1846

Reported from St. Croix by Fries.

**Pogonomyces hydroides** (Sw.) Murrill, Bull. Torrey Club 31: 609. 1904.

*Boletus hydroides* Sw. Prodr. 149. 1788.

Collected on old wood.

? **Poria Alabamae** (Berk. & Cooke) Cooke, Grevillea 14: 113. 1886.

*Polyporus Alabamae* Berk. & Cooke, Grevillea 6: 130. 1878.

Collected on old branches.

**PSILOCYBE ANTILLARUM** (Fries) Sacc. Syll. Fung. 5: 1052. 1887.

*Agaricus Antillarum* Fries, Elench. Fung. 1: 42. 1827.

Reported from St. Croix by Fries.

\* **PYCNOPORUS SANGUINEUS** (L.) Murrill, Bull. Torrey Club 31: 421. 1904.

*Boletus sanguineus* L. Sp. Pl. ed. 2. 1646. 1762.

Collected on old wood. Also reported by Millsbaugh under the name of *Polystictus sanguineus*.

**Schizophyllum alneum** (L.) Schroet. Krypt.-Fl. Schles. 3<sup>1</sup>: 553. 1889.

*Agaricus alneus* L. Sp. Pl. 1176. 1753.

Collected on old sticks.

**Stereum papyrinum** Mont. Pl. Cell. Cuba 374. 1838. ?

Collected on charred wood.

**Tomophagus Colossus** (Fries) Murrill, Torrey 5: 197. 1905.

*Polyporus Colossus* Fries, Nov. Symb. 56. 1851.

Collected inside an old stump near Christiansted.

Dr. Murrill makes the following note<sup>1</sup> on the species: "Plants collected by Millspaugh No. 57838 in Yucatan appear to be immature specimens of the above species. Oersted's original plants are still preserved at Upsala. Further tropical exploration will doubtless discover more of this remarkable species."

Our plants collected in St. Croix while similar to those taken by Millspaugh are very much lighter in weight and the hymenium much thicker. The distribution of the species according to Murrill (N. Am. Fl. 9: 30. 1907) is Costa Rica, Yucatan and doubtfully reported from St. Jan. If the determination of our specimens is correct it would tend to confirm the report of the species from the neighboring island of St. Jan. Our specimens are eight or ten inches across, three inches thick and almost as light as cork.

? *Trametes lignea* Murrill, N. Am. Fl. 9: 44. 1907.

Collected on old wood.

#### DACRYOMYCETALES

*Guepinia Spathularia* (Schw.) Fries, Elench. Fung. 2: 32. 1827.

*Merulius Spathularia* Schw. Schr. Nat. Ges. Leipzig 1: 92. 1822.

Collected on charred wood.

#### LYCOPERDALES

*CYATHUS AMBIGUUS* Tul. Ann. Sci. Nat. III. 1: 75. 1844.

Reported by Børjesen & Paulsen.

*CYATHUS POEPPGII* Tul. Ann. Sci. Nat. III. 1: 77. 1844.

Reported by Millspaugh on manure.

*CYATHUS VERNICOSUS* (Bull.) DC. Fl. Fr. 2: 270. 1815.

*Nidularia vernicosa* Bull. Herb. Fr. pl. 488, f. 1. 1790.

Reported by Børjesen & Paulsen.

*Diplocystis Wrightii* Berk. & Curt.: Berk. Jour. Linn. Soc. 10: 344. 1868.

Collected on sandy ground.

<sup>1</sup> Bull. Torrey Club 32: 474. 1905.



## TREMELLALES

**Exidia glandulosa** (Bull.) Fries, Syst. Myc. 2: 224. 1822.

*Tremella glandulosa* Bull. Champ. Fr. pl. 420, f. 1. 1788.

Collected on bark.

## DOUBTFUL SPECIES

*Polyporus resinosus* (Schrad.) Fries.

Reported by Børghesen & Paulsen but thought to be due to mis-determination or error.





A photograph of culture 16 (left) and *P. roqueforti* (right) grown on petri dishes on potato agar. The white patches of closely interwoven hyphae are shown on the *P. roqueforti*.

# THE MOLD ASSOCIATED WITH THE RIPENING OF BLUE VEINED CHEESE

N. S. GOLDING

(WITH PLATE 2)

## INTRODUCTION

Three years ago an investigation was commenced in the laboratory of the University of British Columbia, with the object of ascertaining, if possible, a suitable procedure for the making of Wensleydale cheese, on the Pacific Coast of North America (1). Some highly satisfactory cheeses have been made, but a rather high percentage of poorer cheeses also resulted. Therefore, it was thought to be desirable to isolate, from several cheeses of good and poor quality respectively, the mold associated with the ripening of these cheeses, and as fully as possible to examine the cultural and morphological characters of the molds recovered. Such striking differences have been found between the pure cultures of the molds isolated from the Wensleydale cheese and from a pure culture of known *Penicillium roqueforti* that the preliminary report may well be published, in spite of the fact that the work is still in progress. It is to be observed that an important phase of the investigation which has not yet been brought to completion is the making of cheese inoculated with the molds dealt with herein.

Considerable work has been done on the organisms associated with the ripening of blue veined cheese, more particularly with the Roquefort and Stilton varieties. From these investigations, the mold *Penicillium roqueforti* (Thom) [*P. glaucum* (Link)] is considered to be, in the case of Roquefort cheese, the only mold that plays an important part in the ripening of this variety (2) (3) (4). Thom (6) states, "Although it (*P. roqueforti*) is not restricted in its habitat to cheese, this species is so identified with the ripening process of Roquefort cheese (in which pure cultures are

used) that anyone desiring a culture of this species can always obtain it by purchasing cheese of this type."

The dominance of *P. roqueforti* in the ripening of Roquefort cheese is attributed to (a) *P. roqueforti* being able to grow in an atmosphere very low in oxygen (2), and (b) the high percentage of salt, about 4 per cent in Roquefort, inhibiting the growth of certain other molds (4).

In the case of English Stilton cheese the same mold is reported to be the only dominant mold associated with the ripening of the cheese (3) (5).

With Wensleydale cheese less work has been done. Steuart (3) reports that in a Wensleydale cheese he examined, the cheese not being true to type, he found the dominant mold to be a type other than *P. roqueforti*. Steuart does not classify this mold, but in a later part of the same work he reports that when making Wensleydale cheese and inoculating with a pure culture of *P. roqueforti*, excellent cheeses were obtained.

#### METHODS AND MATERIALS

*Method of manufacture.*—In the experimental work undertaken for the purpose of ascertaining a suitable procedure for the manufacture of Wensleydale cheese (1), it was at once recognized that inoculation was especially necessary, when cheeses of this type were to be made in an entirely new district. Two alternatives were available:

1. Inoculation with a pure culture of *P. roqueforti*.
2. The following of the older practice of inoculating with a small piece of good quality, well ripened Wensleydale cheese obtained from a reliable dairy.

As the factors concerned in the ripening of Wensleydale cheese have not been fully investigated, it was thought safer to follow the older method. During the process of making, the curd was inoculated with a small piece of Wensleydale cheese obtained from the Midland Agricultural and Dairy College, Kingston, Derby, England. By this method it was hoped to introduce all the biological factors associated with the ripening of the cheese. Subsequently, pieces of cheese made in the laboratory of the University of British

Columbia were used for inoculation. One of these constituted the inoculum used for each of the eight cheeses selected for mycological examination. These eight cheeses were judged by Professor Todd of the Dairy department, University College, Reading, England. In this report he states: "I enclose you a criticism of the samples of cheese sent to me which arrived last week. On the whole, I would consider them quite a good lot and you have certainly managed to get hold of the right mold, and though, in some cases, the texture was much too firm and 'cheddary,' I think that with a little experience you ought to be able to produce a first-rate cheese."

*Method of isolation.*—Samples of all the cheeses judged by Prof. Todd were kept in cold storage and used for mycological examination. In isolating the molds a piece of the outside of the cheese was seared off with a red hot knife. From this cut surface a plug of cheese was taken with a sterile trier, and placed in a petri dish. A small quantity of the blue veined part of the plug was taken and qualitatively plated in three dilutions in duplicate. All the plates were poured with potato agar (7) and incubated at 21° C. for three days. In each case, after inoculation, the plates showed a blue-green mold. This mold appeared to be the dominant growth and formed 90 per cent to 100 per cent of all micro-organisms present; while in many cases the growth was a pure culture of the mold.

In order to determine whether or not other organisms were present to a greater extent in the complete plug, two plugs from different cheeses were ground up in sterile water—10 c.c. to each plug—and from these suitable dilutions, plates were made. The results showed no appreciable difference from those previously obtained and reported above.

The determinations showed a dominant green mold to be present in all the ripened cheeses. Sub-cultures of this mold were made from the potato-agar plates that were inoculated from the blue veins of the cheese.

No work was done with the other organisms that grew on the plates.

For comparison with the mold isolated from Wensleydale

cheese, a pure culture of *P. roqueforti* was obtained from the Dairy Division, Washington.

*Media*.—For determining the cultural and morphological characters, the following media were used:

*Potato agar + 2 per cent dextrose*: as described by Thom (7).

*Plain gelatin*: 15 per cent gelatin dissolved in distilled water, tubed and sterilized, under 15 lbs. pressure for 20 minutes.

*Whey-peptone-litmus-gelatin*: Preparation of whey. To 1½ gallons of sweet skim milk at 37° C. rennet was added at the rate of 1 dram rennet per gallon of milk and stirred well. The milk was then left for 30 minutes to clot, after which the curd was broken with a spoon, and the whey expelled by the heating of the whole, on a water bath to 45° C.: 3,000 c.c. of the whey were decanted off and divided into two equal parts. To the one part 450 grams of gelatin were added and heated on a water bath until dissolved. To the second part of the whey 30 grams of peptone were added and heated and stirred till dissolved. The whole was mixed, two eggs were added, the medium heated for 30 minutes under pressure, filtered and brought to an acidity of +1.0 to phenolphthalein by adding the required quantity of normal NaOH. A sufficient amount of litmus solution previously prepared was added, and the media tubed and sterilized under a pressure of 15 lbs. for 30 minutes.

*Plain gelatin and saccharose*.—To a 15 per cent gelatin prepared in distilled water, 3 per cent cane sugar was added, and the whole tubed and sterilized under a pressure of 15 lbs. for 20 minutes.

#### MORPHOLOGICAL CHARACTERS

In the examination of the molds isolated from the various cheeses, the cultural characters of each mold appeared to be identical as far as examined. The following description is therefore applicable to each sub-culture isolated. The Wensleydale mold grows quickly and luxuriantly on potato agar, and on whey gelatin. On gelatin and saccharose gelatin the growth is fair, and on plain gelatin growth is scant. On potato agar the colonies begin to form spores about the second or third days, the spore area varying from grey green to blue grey, turning dirty brown with age.

The margin of the colony is white, strict, and uneven; though the margin can always be described as broad. The underside of the colony is grass green under the spores, and colorless under the margin. The conidiophores arise separately and in acropetal succession from the submerged hyphae, their length being very varied, but seldom greater than  $250\ \mu$ . The conidial fructification is loose, and has a length up to  $100\ \mu$  but shows considerable variation. The conidia are oval to round, and have a diameter from  $3\ \mu$  to  $6\ \mu$ . The colonies do not liquefy gelatin. In the whey-peptone-litmus-gelatin there is a general tendency to produce acid, though the mold could not be said to be a rapid acid producer.

In comparing the cultural characters of *P. roqueforti* with those of the Wensleydale mold there is a close similarity except as detailed below.

1. In the colonies of *P. roqueforti* there were white patches of closely interwoven hyphae, which in some cases would be more than a centimeter in diameter; these areas never occurred with the Wensleydale mold, fig. *a*.

2. The reverse of the colony of *P. roqueforti* in potato agar was always yellow and not green, as in the case of the Wensleydale mold.

3. The *P. roqueforti* never produced acid in whey gelatin.

#### PHYSIOLOGICAL CHARACTERS

*Digestion of casein.*—The data recorded thus far show that the mold from the Wensleydale cheese could not be considered as being identical with *P. roqueforti*. Quantitative determinations were made, therefore, of the degree to which the respective molds digested the casein of skim milk and the casein of acid skim milk respectively. Test tubes containing 15 c.c. sweet skim milk—the milk formed a depth of  $1\frac{1}{2}$  in.—were plugged, sterilized, inoculated with the required mold and incubated at room temperature for 11 days—table I.

In preparing the acid skim milk 75 c.c. of skim milk were sterilized in an Erlenmeyer flask, cooled and acidified with 10 c.c. of sterile lactic acid solution having an acidity of +21.2. Ten c.c. of this milk was then pipetted under sterile conditions into large



test tubes. The tubes, which had a depth of about 1 in. of milk, were then inoculated and incubated at room temperature for 11 days—table I.

TABLE I

THE DIGESTION OF CASEIN IN SKIM MILK AND ACID SKIM MILK  
CULTURES GROWN AT ROOM TEMPERATURE IN TEST TUBES  
FOR 11 DAYS

## SKIM MILK (15 C.C.)

Cultures	Percentage of casein	Percentage soluble nitrogen expressed as protein	Percentage of casein digested
Uninoculated control.....	a. 2.67 b. 2.67 c. 2.71	.60 .55 .63	
Average.....	2.68	.59	
<i>P. roqueforti</i> .....	a. 2.19 b. 2.17	1.16 1.05	
Average.....	2.18	1.10	18.6
Culture 15 (from Wensleydale cheese made May 29th, 1922).....	a. 2.54 b. 2.58	.73 .72	
Average.....	2.56	.72	

## ACID SKIM MILK (10 C.C.)

Cultures	Percentage of casein	Percentage soluble nitrogen expressed as protein	Percentage of casein digested
Uninoculated control.....	a. 2.74 b. 2.72	.76 .86	
Average.....	2.73	.81	
<i>P. roqueforti</i> .....	a. 1.56 b. 1.80	1.95 1.04	
Average.....	1.68	1.79	38.8
Culture 16 (from Wensleydale cheese made Aug. 3, 1922).....	a. 2.59 b. 2.41	1.10 1.10	
Average.....	2.50	1.10	

TABLE II

THE DIGESTION OF CASEIN IN SKIM MILK AND ACID SKIM MILK  
CULTURES GROWN AT ROOM TEMPERATURE IN ERLLENMEYER  
FLASKS FOR TEN DAYS

## SKIM MILK

Cultures	Percentage of casein	Percentage soluble nitrogen expressed as protein	Percentage of casein digested
Uninoculated control. ....	<i>a.</i> 2.79	.57	74.6
	<i>b.</i> 2.79	.58	
Average. ....	2.79	.57	
<i>P. roqueforti</i> . ....	<i>a.</i> .70	2.61	
	<i>b.</i> .73	2.61	
	<i>c.</i> .69	2.66	
Average. ....	.71	2.63	17.9
Culture 16 (from Wensleydale cheese made Aug. 3, 1922).....	<i>a.</i> 2.36	1.11	
	<i>b.</i> 2.28	1.01	
	<i>c.</i> 2.22	1.16	
Average. ....	2.29	1.09	

## ACID SKIM MILK

Cultures	Percentage of casein	Percentage soluble nitrogen expressed as protein	Percentage of casein digested
Uninoculated control. ....	<i>a.</i> 2.32	.74	68.6
	<i>b.</i> 2.41	.58	
Average. ....	2.36	.66	
<i>P. roqueforti</i> . ....	<i>a.</i> .82	2.13	
	<i>b.</i> .70	2.25	
	<i>c.</i> .70	2.26	
Average. ....	.74	2.21	17.8
Culture 16 (from Wensleydale cheese made Aug. 3, 1922).....	<i>a.</i> 1.90	1.05	
	<i>b.</i> 1.93	1.07	
	<i>c.</i> 1.98	1.03	
Average. ....	1.94	1.05	

Both the skim milk and the acid skim milk tubes, at the end of the incubation period, were analyzed for the percentage of casein left in the milk, by precipitation with acetic acid as given in the A.O.A.C. (8) Kjeldahl, and determinations were made on both the precipitate and the filtrate. The percentage of nitrogen in the former is expressed as casein, and in the latter as soluble nitrogen expressed as protein—tables I and II. Though for comparison the nitrogen in the filtrate has been expressed as soluble protein, it is well to remember that this figure includes all the decomposition products of protein.

Referring to table I, it will be noticed at once that considerable digestion of the casein has taken place with the *P. roqueforti* cultures and only about one fourth as much when using the cultures of the Wensleydale mold. The results of the skim milk cannot be directly compared with the results of the acid skim milk, for the organisms are aërobic and the areas of surface of milk exposed were not identical.

Owing to the great difference in the rate of digestion by the two organisms, the determinations were repeated in Erlenmeyer flasks—table II. The use of the flasks provided for a greater surface area of milk and permitted more specific comparison of results. The results of this experiment—table II—are most striking and very uniform when it is considered that the proportion of inoculation is unavoidably variable. The conclusions to be drawn from tables I and II are:

1. Both *P. roqueforti* and the mold from the Wensleydale cheese digest casein in milk, but the rapidity of digestion of the former is four times that of the latter.

2. The rate of digestion of the casein is much greater where there is a large surface of milk exposed.

3. There is little difference in the rate at which the skim milk and acid skim milk respectively are digested when inoculated with either culture.

*Growth on synthetic media.*—The basic synthetic medium used was that recommended by A. W. Dox (2) (6), details of which medium are given in table III. Using this medium, the ten varieties of the same, as detailed in table III, were prepared. For each

medium, eight 50 c.c. Erlenmeyer flasks containing 20 c.c. of the required medium were prepared, plugged, and sterilized, and inoculated in duplicate with cultures 15, 16 and *P. roqueforti* respectively. Two flasks uninoculated as control were retained. After incubation at 21° C. for 10 days the degree of growth of the mycelium was determined by its weight. The cultures and media were filtered through a Gooch crucible, the mycelium was washed with distilled water, oven dried at 100° C. till constant, and weighed.

TABLE III

WEIGHT OF FELT PRODUCED BY CULTURES IN 20 C.C. OF SPECIFIC MEDIA  
SHOWN GROWN AT 21° C. FOR 10 DAYS IN ERLLENMEYER FLASKS

Medium	Mold from Wensleydale cheese			
	Culture 15, grams	Culture 16, grams	<i>P. roqueforti</i> , grams	Uninoculated, grams
Synthetic medium <sup>1</sup> .....	.0011	.0013	.0010	.0009
" " + 2.5 % saccharose	.0102	.0189	.0512	.0008
" " + 2.5 % lactose....	.0136	.0154	.0088	.0004
" " + 2.5 % galactose .	.0173	.0105	.0321	.0007
" " + 2.5 % levulose ..	.0208	.0175	.0651	.0002
" " + 2.5 % dextrose ..	.0754	.0435	.1008	.0003
" " + 3.0 % peptone...	.0375	.0438	.0268	.0021
" " + 2.5 % lactose + lactic acid.....	.0129	.0066	.0143	.0003
" " + .7 % lactic acid.	.0038	.0036	.0050	.0001
" " + 3.0 % casein....	.0443	.0318	.0225	.0005

Referring to table III, the weights of mycelium representing the degree of growth show the following points of interest:

1. The weights of mycelium from the cultures of *P. roqueforti* are always greater than or less than are those from cultures 15 and 16.

<sup>1</sup> The synthetic medium was Czapek's formula modified by A. W. Dox, Chas. Thom (2 & 6).

2000 c.c. distilled water  
1 gram magnesium sulphate  
2 grams dipotassium phosphate  
1 grain potassium chloride  
.02 gram ferrous sulphate  
4.0 grams sodium nitrate

The casein was obtained in colloidal suspension by the method adapted by S. Henry Ayers (9).

2. In the media containing four of the sugars saccharose, galactose, levulose, and dextrose respectively, *P. roqueforti* produces a much greater growth than do cultures 15 and 16: while the opposite result is obtained in a medium containing lactose.

3. In the medium containing peptone and casein respectively, each of the cultures 15 and 16 produce greater growth than is given by *P. roqueforti*.

4. *P. roqueforti* produces a greater growth where lactic acid is present either with or without lactose than is produced by either cultures 15 or 16.

TABLE IV

NUMBER OF C.C. OF  $n/10$   $\text{Ba}(\text{OH})_2$  NEUTRALIZED BY GAS GIVEN OFF FROM 10 C.C. OF SKIM MILK. CULTURES GROWN IN ELDRIDGE TUBES AT ROOM TEMPERATURE

	Cul- ture	Series A. Inoculated Aug. 6, 23			Series B. Inoculated Aug. 18			
		A Day's growth			B Day's growth			
		2	4	6	2	4	6	8
(From Wensleydale cheese made Aug. 3, 1922).....	16	.4	4.5	6	3.4	7.1	8.2	9.3
(From Wensleydale cheese made May 29, 1922).....	15	.8	4.7	5.6	3.0	6.9	6.7	9.3
<i>P. roqueforti</i> .....		.6	4.2	9.4	2.0	5.3	11.7	16.8
" ".....					2.5	6.8	16.0	13.0

*Carbon dioxide production.*—Eldredge tubes (10) were filled with 10 c.c. of skim milk plugged and sterilized. Eight cultures of the Wensleydale mold and of *P. roqueforti* respectively were then used for inoculation, employing four tubes for each culture. The other side of the tube was filled with 10 c.c.  $n/10$   $\text{Ba}(\text{OH})_2$  and the tubes corked with rubber stoppers. The  $\text{CO}_2$  produced was measured by the reduction in alkalinity of the  $n/10$   $\text{Ba}(\text{OH})_2$  on the second, fourth, and sixth day—table IV-A. As all the  $n/10$   $\text{Ba}(\text{OH})_2$  was used up on the eighth day, a second series—table IV-B—was run using 15 c.c. of  $n/10$   $\text{Ba}(\text{OH})_2$ .

From these determinations, the chief points of interest are:

1. A considerable quantity of  $\text{CO}_2$  is produced by the various cultures of the Wensleydale mold and by *P. roqueforti*.

2. There is no marked difference in the results from any culture till the sixth day, after which the *P. roqueforti* has an increasingly greater  $\text{CO}_2$  production in comparison with any of the Wensleydale mold cultures.

*Temperature relations.*—The object of these determinations was to find the approximate, optimum, maximum and minimum temperature at which the Wensleydale molds would grow, and to compare the same with the growth of *P. roqueforti*.

The molds were grown in Petri dishes on a potato agar medium containing 2 per cent dextrose. The plates were poured, allowed to solidify, and inoculated in duplicate with cultures of the Wensleydale mold and *P. roqueforti* respectively, using a platinum wire. Five incubators were used varying in temperature from  $4.5^\circ \text{C.}$  to  $36.6^\circ \text{C.}$  and duplicate plates of each culture were placed in each incubator—table V.

To express the degree of growth from day to day the decimal method as described by Thom (6) was adopted—table V, footnote. This method proved satisfactory in showing the rate at which the colonies matured. The amount of growth produced, however, would have been more satisfactorily determined by applying the method of weighing the mycelium—defined on page .

Before referring to the results, it should be noted that the slight growth on the first day on the plates incubated at  $36.6^\circ \text{C.}$  was caused by this incubator being at  $32^\circ \text{C.}$  for the first day, but subsequent to this, the temperature remained just under blood heat. The other incubators varied but slightly, and their limits of variation are given in the second footnote of table V.

Referring to the results in table V, the following conclusions may be drawn:

1. All the cultures at the same temperature, including both the Wensleydale molds and the *P. roqueforti*, grow at about an equal rate.

2. None of the cultures grow at blood heat.



EXPLANATION OF DECIMALS: 0.1 denotes germination of conidia only; decimals up to 0.7, growth without the formation of colored conidial areas; 0.7 to 1.0 denotes typical colony.

## LIMIT OF VARIATION OF THE FIVE INCUBATORS

Average	Maximum	Minimum
4.54	6.0	1.5
14.1	14.5	14.
20.6	21.5	18.5
28.9	31.	27.5
36.6	37.5	32.

3. The optimum, maximum, and minimum temperatures, while they cannot be clearly fixed, are shown to be about as follows:

Optimum between 20.6° C. and 28.9° C.

Maximum above 28.9° C. and below 36.6° C.

Minimum below 4.5° C.

It is not possible at this stage to conclude whether or not the differences as shown in this work justify an assumption that the Wensleydale mold and *P. roqueforti* may be considered as different varieties of the same species, or different species. Work on this phase of the investigation is still in progress.

## SUMMARY

The dominant mold obtained from the Wensleydale cheese is not identical with *P. roqueforti*. There is at least one marked difference in the structure of the colonies on potato agar. The *P. roqueforti* produces large white areas of closely interwoven mycelium. These have never been noticed in the case of the Wensleydale strain.

The reactions on some of the constituents of the media used are different. This difference is usually more a question of degree of growth or rate of change than a direct positive or negative result. These differences may be briefly summed up as follows:

1. The Wensleydale strain produces a slight degree of acidity in whey-peptone-litmus-gelatin, while *P. roqueforti* does not.

2. The digestion of the casein of milk which has been inoculated with *P. roqueforti* is four times as rapid as is the case when milk is inoculated with the Wensleydale mold.



3. The Wensleydale strain grows less freely than does *P. roqueforti* on synthetic medium containing saccharose, galactose, levulose, and dextrose, respectively.

4. The Wensleydale strain grows more freely on synthetic media containing casein and peptone respectively than does *P. roqueforti*.

Thanks are tendered to the Departments of Botany and Dairying of the Iowa State College, U. S. A., and to the Department of Dairying of the University of British Columbia, Canada, for facilities granted and assistance given.

UNIVERSITY OF BRITISH COLUMBIA

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# CORYNEUM RUBORUM OUD. AND ITS ASCOGENOUS STAGE

S. M. ZELLER

(WITH PLATE 3)

## INTRODUCTION

A *Coryneum*, which answers in every morphological character the description of *Coryneum Ruborum* Oud., is widespread in Western Oregon. As suggested by the specific name the genus *Rubus* is host for this organism. It has been observed on several varieties of red and black raspberry (*Rubus strigosus* Mich. and *R. occidentalis* Linn., respectively). The pathogenicity of the organism has not been determined, so that the writer has no information on the exact amount of damage done, although the infections have a general range in the raspberry plantings of all the fruit growing districts in the western part of the state.

## GENERAL DESCRIPTION OF LESIONS

The lesions are found on the fruiting canes, the first appearance being noticed in the late fall and winter months when the epidermis of the affected portions becomes brownish on red raspberry and bluish on black raspberry canes. Later these same areas become ashen on red varieties and bluish with a silvery bloom on black varieties of raspberry. The affected areas are usually from 7-20 cm. long and as a rule do not extend completely around the stems. In the earlier stages of infection the discoloration of the host tissues extends to a depth of but a few cells below the epidermis. There seems to be no evidence, without artificial inoculations, that the fungous invasion extends much deeper before harvest of the berry crop the following summer. Inoculations will be carried out during the present season to determine the symptoms during the progress of lesion formation and the damage done to affected canes. In the early spring, February and March, the affected areas become dotted with reddish brown spots, ranging in size

from  $120\ \mu$  to  $350\ \mu$ , which are the acervuli. After the dark-fuliginous conidiospores have been discharged the bark immediately surrounding the pustules takes on a sooty appearance. At this time of year the epidermis of the lesions usually remains intact but in some cases the epidermis cracks in longitudinal and circumscribing lines and peels back giving a shaggy appearance to the cane (See Fig. 1).

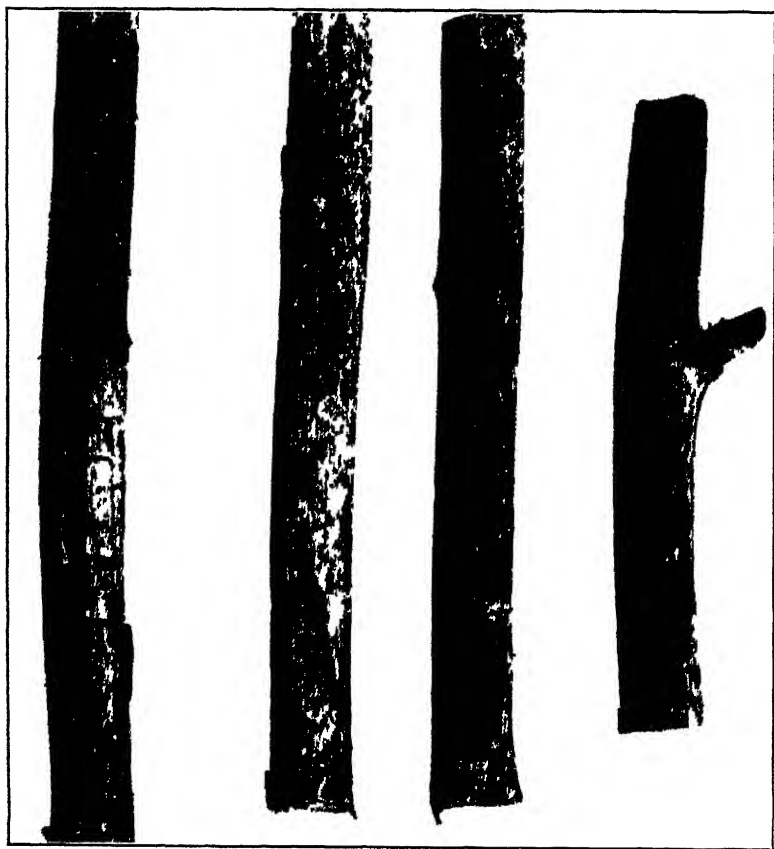


FIG. 1. Canes infected with *Corneum Ruborum*

The lesions usually center around nodes or run downward from a node. For this reason there is some indication that infection may take place through leaf scars, cracks in the axles of buds or

branches, and in the case of black raspberry, cane infection has been noted at pruning cuts. In a few cases internode lesions without evident wounds have been observed.

The acervuli begin to appear in late August and early September. In the fall of 1923 the first appearance in the Ashland District of the Rogue River Valley was toward the middle of September while in the Willamette Valley the acervuli were seen during the first week in August. From this time in early fall until June of the following spring acervuli are found liberating conidia. This period of conidiospore liberation corresponds with the period of infection by *Coryneum Beijerinckii* Oud. for the same districts.

The ultimate longevity of the spores of *Coryneum Ruborum* is not known but we do know that they will withstand desiccation of room temperatures for two years. Conidiospores from red raspberry canes collected by H. P. Barss, April, 1922, were plated out in potato glucose agar Mar. 31, 1924, and on Apr. 10 there was evidence of nearly 100 per cent germination. Smith<sup>1</sup> says that the conidia of *Coryneum Beijerinckii* appear to live through the summer in California lodged in the bud scales of peach and are thus very resistant to desiccation.

#### ASCOGENOUS STAGE DESCRIBED

On March 12 of last year the ascogenous stage of *Coryneum Ruborum* was discovered by the writer on two-year-old canes of Cuthbert red raspberry which were lying on the soil in an unattended planting. More material was secured on April 21. On these weathered and partially decayed canes the epidermis was loose but dotted by the erumpent acervuli of the *Coryneum* stage as well as perithecia of an ascomycete. Upon diagnosis the latter proved to belong to the genus *Ascospora*. Since Vuillemin<sup>2</sup> had referred to the connection of *Coryneum Beijerinckii* Oud. with an *Ascospora*, the present discovery of acervuli of *Coryneum Ruborum* Oud. in close proximity to perithecia of *Ascospora* on *Rubus* became of immediate interest.

<sup>1</sup> Smith, R. E. California peach blight. Calif. Agr. Exp. Sta. Bull. 191: 73-98. 1907.

<sup>2</sup> Vuillemin, P. L'*Ascospora* Beijerinckii et la maladie des Cerisiers. Jour. de Bot. 2: 255-259. f. 1-2. 1888.

In March many immature perithecia of this *Ascospora* were observed, but the majority were mature and discharging ascospores. It is evident, then, that ascospores begin to be liberated in early March and an observation on April 21 showed no immature perithecia present on the lesions collected at that time.

The perithecia are variable in size from  $100\ \mu$  to  $200\ \mu$ . They are carbonaceous and depressed globose, and the walls are from one to three cells thick. The ostiole is very small, circular to lenticular, not papillate. The perithecia are usually erumpent, seated upon a subepidermal layer of ramifying, brown mycelium, which is thickened into a pseudoparenchyma directly beneath the perithecia. The branches of the mycelium usually extend in the direction of the long axes of the cells of the host tissue. This character is illustrated in figures 4 and 5 in plate 3. Figure 4 shows a perithecium and ramifying mycelium on the host tissues after the epidermis has been lifted away.

The asci come from the crushed perithecia in fascicles, attached at the base. They measure  $40\text{--}55\ \mu$  by  $9\text{--}12\ \mu$ , are cylindrical to curved and contain 8 spores surrounded by epiplasm which is more or less distinctly attenuated above and below the line of spores, which are one to two seriate.

Paraphyses are not found among the asci.

Ascospores are hyaline, unicellular, ellipsoid, obtuse at both ends,  $10\text{--}13 \times 4\text{--}5\ \mu$ .

#### SPORE DISCHARGE

In water the epiplasm of an ascus evidently has great powers of imbibition under which condition the ascus greatly elongates. In this process of elongation the wall of the ascus remains rigid in its original form, merely the apical portion assuming a gelatinized condition and expanding to allow the inner sheath (or plasma membrane?) to elongate under pressure into a tube, usually exceeding the length of the ascus below. The upper end of the ascus-wall is defined by a very fine line. The spores are slowly carried by the epiplasm into the elongated tube. Finally the tension of the apical membrane, which doubtless becomes thinner and less dense, suddenly breaks and the spores are forcibly ejected for some distance.

In the case of *Ascospora Beijerinckii* (Oud.) Vuil. the ascospores were observed by Vuillemin to be projected to a distance of two millimeters under water, "in spite of the resistance of the water and the friction of the glass." This type of spore ejection has been observed by other members of the staff at this laboratory in other species of ascomycetes. Among these were *Mycosphaerella rubina* (Peck.) Jacz., *Venturia inaequalis* (Cooke) Aderhs., *Plowrightia ribesia* (Pers.) Sacc., and perhaps, many others disperse spores in a like manner but the details of the process are seldom referred to in literature.

To determine whether this is the manner in which ascospores are ejected from the perithecia of this species the following observation was made. A piece of subepidermal tissue with perithecia was placed in water for about 15 minutes and then placed under the microscope for observation. After about 20 minutes in water tiny pearly white bodies were seen to appear in the ostioles. Some times three crowded out together. Under the high (dry) power of the microscope a few of these could be identified as asci protruding from the ostioles. This illustrates the necessity of accumulated moisture to bring about spore discharge in this species, *i.e.*, such moisture as might accumulate on berry canes after rain or condensation from high atmospheric humidity. It is probable then that ascospore discharge in Oregon is limited to the period from about the first of March until the end of the rainy season or such time when foggy nights are not frequent.

#### CONNECTION BETWEEN ASCOGENOUS AND CONIDIAL STAGES ESTABLISHED

Cultures of two types have been secured of the organism in question, *i.e.*, those from the conidiospores and those from ascospores.

In the first case spores from the *Coryneum* acervuli were diluted in the usual way and poured Petri-dish plates of potato glucose agar were prepared. Colonies from individual spores were transferred from such plates to agar slants.

In the case where cultures were prepared from ascospores the method of ejection of spores from the ascus, described above, was

taken into consideration. Since *Coryneum* spores were present in nearly all water mounts they were first washed away. In order to do this a cluster of asci were held with a sterile needle against a microscope slide while the slide was repeatedly rinsed with sterile water from a wash bottle. After this process a microscopic examination showed no *Coryneum* spores present. Now by pressure on the cover glass the asci were forced apart until an individual ascus could be picked up in a fine capillary glass tube. After this was accomplished the tube was deposited horizontally in a damp chamber until the ascus had discharged its spores. Five different asci were so treated and the remaining asci which still clung together were drawn into a capillary tube and treated likewise. None of the asci discharged all of their spores, as observed under the microscope, from one to four remaining in an ascus. Then, the contents of the six capillary tubes were blown into test tubes of potato glucose agar and after agitation Petri-dish plates were poured in the usual way. The plates were poured on March 14 and colonies of fungi and bacteria which appeared on the plates were each transferred to agar slants in test tubes on March 18 and 20. Sixty-two such transfers were made, out of which 36 colonies had yielded pure cultures of *Coryneum Ruborum* Oud., while the remainder were contaminations of bacteria and *Penicillium*.

The results of the poured plates are given in the accompanying table.

TABLE I  
RESULTING COLONIES OF *Coryneum* FROM GERMINATION OF ASCOSPORES  
OF *Ascospora*

Capillary tube	Number of spores discharged from ascus	Colonies of <i>Coryneum Ruborum</i> resulting from ascospores	Remarks
a	5	5 out of possible 6	3 bacterial colonies
b	none	1 " " " 1	3 <i>Penicillium</i> colonies 8 bacterial colonies
c	6	6 " " " 7	
d	4	5 " " " 5	11 bacterial colonies
e	7	7 " " " 8	
f	many	12	1 <i>Penicillium</i> colony

It will be noticed that a few of the ascospores were lost, probably in the agar adhering to the test tubes after pouring the plates.

The writer is certain that no *Coryneum* spores were in the capillary tubes and that the *Coryneum* colonies resulted from the germination of the ascospores of the *Ascospora*. The *Coryneum* cultures obtained in this manner are in every particular similar to those obtained from *Coryneum acervuli* on the host plants. In Plate 3 the conidiospores from the host are illustrated in figure 2, while figure 3 illustrates conidia produced in culture from ascospores of *Ascospora*.

When cultures of the organism are transferred to a medium of sweet clover stems (*Melilotus alba*), the more or less typical acervuli are formed, although superficial rather than erumpent.

#### AFFINITIES OF *Ascospora* STAGE

The *Ascospora* in question differs from other described species of the genus. Its nearest affinities in a morphological sense are with *Ascospora Beijerinckii* (Oud.) Vuillemin, although there are several distinct points of difference. The asci average smaller as do also the ascospores.

If Vuillemin's hypothesis, that *Coryneum Beijerinckii* Oud. is the imperfect stage of *Ascospora Beijerinckii*, is to be accepted without cultural evidence, the affinity of this species with the one found on *Rubus* is a close one. However, the conidia of the two species are distinct in size, color and septation, the latter having conidia darker in color, averaging  $14 \times 6.5 \mu$ , and invariably 3-septate, while those of the former are lighter in color,  $30-45 \times 14-17 \mu$ , and 1-5-septate. The two species are also distinct in host relationship.

Since the organism described in detail above has been proven to be the ascogenous stage of *Coryneum Ruborum* Oud., the new combination ***Ascospora Ruborum*** (Oud.) becomes necessary and the following condensed description is perhaps desirable in this connection.

#### CONDENSED DESCRIPTION

***Ascospora Ruborum*** (Oud.) Zeller n. comb.

*Perithecia* at first subcuticular, becoming erumpent, 100-200  $\mu$ , carbonaceous arising from a ramifying cushion of dark mycelium



which is pseudoparenchymatous directly beneath; *walls* thin; *ostiole* small, circular to lenticular, not papillate; *asci* cylindric, inequilateral, mostly larger below, hyaline, 8-spored with a distinct epiplasm.  $40-55 \times 9-12 \mu$ , elongating before spore discharge; *paraphyses* none; *ascospores* ellipsoid, obtuse at both ends, hyaline seldom guttulate,  $10-13 \times 4-5 \mu$ .

Conidial stage, *Coryneum*. *Acervuli* erumpent, breaking irregularly,  $120-350 \mu$ ; *conidiophores* from a subepidermal pseudoparenchyma, slender, hyaline,  $18-32 \mu$  long; *spores* ellipsoid, more obtuse at the apical end, dark fuliginous, 3-septate,  $11-18 \times 6-7 \mu$ .

On fruiting canes of *Rubus*.

Specimen examined—*Ascospora* stage.

Corvallis, S. M. Zeller, type (in Zeller Herb. 2638, 2654, in O. A. C. Herb. 3751).

*Coryneum* stage.

Corvallis, S. M. Zeller (in Zeller Herb. 2481, 2488, 2638, 2640, 2654); Ashland, S. M. Zeller (in Zeller Herb. 2547), F. C. Reimer (in Zeller Herb. 2632); Springbrook, S. M. Zeller (in Zeller Herb. 2646); H. P. Barss (in O. A. C. Herb. 3752).

## SUMMARY

A description of the characteristics of lesions on canes of red and black raspberries caused by *Coryneum Ruborum* Oud. is given. The technique involved in obtaining pure cultures of this organism from the ascospores of the perfect stage, *Ascospora Ruborum* (Oud.) Zeller, is also described.

OREGON AGRICULTURAL EXPERIMENT STATION,  
CORVALLIS, OREGON

## DESCRIPTION OF PLATE 3

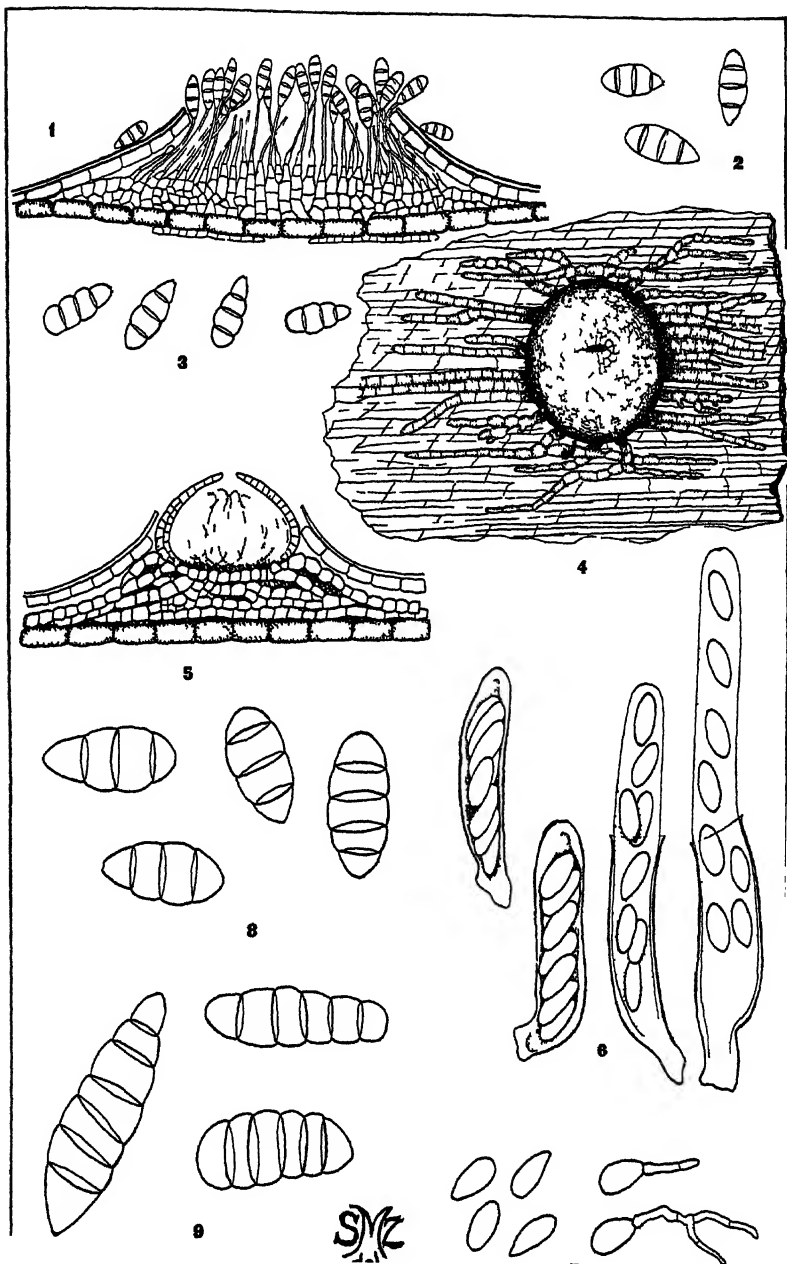
### *Camera lucida* drawings

Fig. 1. Vertical longitudinal section of an acervulus of the *Coryneum* stage of *Ascospora Ruborum*.  $\times 200$ .

Fig. 2. Conidiospores of the same fungus from the host, *Rubus strigosus*.  $\times 666$ .

Fig. 3. Conidiospores from a culture obtained from the germination of an ascospore of *Ascospora Ruborum*.  $\times 666$ .

Fig. 4. Perithecium of *Ascospora Ruborum* showing the ramifications of the subepidermal mycelium after the epidermis has been lifted away.  $\times 200$ .



CORYNEUM AND ASCOSPORA



Fig. 5. Vertical section of an erumpent perithecium showing a section of the subepidermal mycelium with its pseudoparenchymatous character beneath the perithecium.  $\times 200$ .

Fig. 6. Asci of *Ascospora Ruborum*, two of which show the elongation of the inner membrane when the epiplasm imbibes water. Through such elongation the ascus extends through the ostiole before the spores are discharged.  $\times 666$ .

Fig. 7. Ascospores, two of which have germinated.  $\times 666$ .

Fig. 8. Conidiospores of the *Coryneum* stage of *Ascospora Beijerinckii* (Oud.) Vuil. From an acervulus on peach bark.  $\times 666$ .

Fig. 9. Conidiospores of the same fungus from culture.  $\times 666$ .

## NOTES AND BRIEF ARTICLES

The first four parts of "Icones Fungorum Malayensium" have recently appeared. It is the intention to issue twelve parts per year, each part to consist of one finely colored plate with a number of figures of the fungi of the Dutch East Indian Archipelago, accompanied by descriptive text in German. The first four parts are devoted to the Clavariaceae.

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Under the title "Notes on parasitic fungi in Wisconsin IX-X-XI," in the Transactions of the Wisconsin Academy of Sciences 21: 251-302, Dr. J. J. Davis described the following new species: *Ramularia tenuis* on the leaves of *Solidago latifolia*; *Synchytrium cinnamomeum* on *Ranunculus recurvatus* and *Ranunculus septentrionalis*; *Synchytrium nigrescens* on *Aster lateriflorus*; *Macrophoma arens* on *Koeleria cristata*; *Asteromella astericola* on *Aster lateriflorus*; *Stagonospora albescens* on *Carex tribuloides*; *Septogloeum querceum* on *Quercus bicolor*; *Cercospora Molluginis* on *Mollugo verticillata*; *Tuberculina argillacea* on *Rubus allegheniensis* and *Rubus occidentalis*; *Phyllosticta Ambrosiae* on *Ambrosia trifida*; *Septoria cenchrina* on *Cenchrus carolinianus*; *Colletotrichum Violarum* on *Viola scabriuscula*; *Septogloeum subnudum* on *Smilax herbacea*; *Cladosporium caducum* on *Betula nigra*; *Cercospora crassoides* on *Froelichia floridana*; *Puccinia Caricis-shepherdiae* on *Carex eburnea*.

### THE SNAPDRAGON RUST

Attention has recently been called to the destructive work of the snapdragon rust known scientifically as *Puccinia Antirrhini* Diet. & Holw. A New York correspondent, Mr. H. A. Gibbs, writes as follows: "The disease appeared first five years ago on plants outside in the garden. The following year seedlings were grown

in the greenhouse and were immune. Next year I did not grow any of this kind of plant at all, but in 1922 we lost fully 1,000 plants which had arrived at about the height of this sent herewith. In 1923 we got about 85 per cent of the plants free from disease, but these were removed from the greenhouse and put into cold frames and after that very little rust appeared."

This fungus was originally described from material collected in California, the description being published by a German in a European botanical journal, in 1895. The California specimens were collected by W. C. Blasdale, who in a note published in 1903 states that the fungus has appeared there every year since and in every case destroyed the plants shortly before they had reached the flowering stage.

In 1913 the fungus was reported as responsible for a great deal of damage to the cultivated snapdragon in the vicinity of Chicago. The disease continued to spread rapidly until it is now found wherever the host is grown in the greenhouse.

Beautifully rusted specimens have been received from the correspondent quoted above and since the matter may be of interest to others it is thought well to publish this brief note. While the fungus is well known and widely distributed in this country the control methods have not been very satisfactorily worked out. We will publish a summary of the work done along this line in Illinois.

### *Control*

The control methods recommended by Mr. George L. Piltier of the Illinois Experiment Station, where a great deal of damage has been done and many experiments conducted, are as follows:

"Snapdragon rust may be partially controlled in the greenhouse by giving attention to cultural methods. Growing the plants under the best conditions in a clean, well-kept, and well-ventilated house will check to some extent the dissemination of the disease. Plants should not be syringed if this can possibly be avoided but instead the soil only should receive water when the plants require it.

"In order to eliminate the rust, it is recommended that all infected material be destroyed, the house cleaned, and after a year or

two new stock secured which is free from rust. The latter may be secured by the use of seed and the practice of selection."

FRED J. SEAVER

#### BOTANIZING IN VIRGINIA

On October 18 I drove with a party of friends to Danville, 73 miles south of Lynchburg, stopping at several points on the way. Chatham was the most interesting town seen en route, reminding me of Bedford but lacking its elevation and its splendid view of the Peaks of Otter. The vegetation gradually acquired elements of the coastal flora as we approached Danville; well-built barns for bright-leaf tobacco became abundant; and finally the road was bordered with fields of cotton.

What could be more beautiful than a Virginia autumn, when the days are warm, the nights studded with stars, and the woods crimsoned with black gum, sourwood, and sumac! In Sweden and our Northwest, the aspen poplar brightens the gloom of the coniferous forest at this season, but in Virginia the flame of the giant poplar rises gloriously above all competitors and may be seen for miles.

Fungi were few because of the dry weather, but those found were characteristic. The deadly *Amanita* in its white form, the fly *Amanita*, the honey agaric so destructive to oaks, several kinds of *Russula*, the edible fall *Boletus* (*Rostkovites granulatus*), four species of puffballs, most of them ripe and ready to distribute their millions of dust-like spores, and many smaller fungi found on dead wood, indicated to me that little if any change takes place in the fungous flora between Lynchburg and Danville.

W. A. MURRILL







PHILLIPSIA CHARDONIANA SEEVER

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No. 2

## STUDIES IN TROPICAL ASCOMYCETES—III PORTO RICAN CUP-FUNGI

FRED J. SEAVER

(WITH PLATE 4)

During a recent trip in Porto Rico, January 24 to April 5, 1923, a number of species and genera of cup-fungi were collected, and others have been since sent in for determination, which are apparently undescribed, or at least new to the island. The present paper includes descriptions and notes on a number of such species and genera and is preliminary to a more thorough treatment of the fungi in the Botany of Porto Rico and the Virgin Islands in preparation by the New York Academy of Sciences.

While the fungi, especially the parasitic fungi, have been very thoroughly collected in Porto Rico, the cup-fungi have been overlooked and neglected. It is hoped that this preliminary list will help to arouse interest in the group and stimulate local collectors to search more diligently for these neglected forms. The collection of two species of Geoglossaceae, a family which so far as we know had not been previously reported from the island, would indicate that many more of such interesting forms may be represented there.

### A. OPERCULATE SERIES

#### *Cookeina tetraspora* sp. nov.

Apothecia gregarious or becoming confluent and occasionally several fused together, the hymenium plane or slightly concave, pale orange, reaching a diameter of 3–5 mm., externally whitish, strongly wrinkled, clothed with delicate fasciculate hairs; asci

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clavate, reaching a length of  $200\ \mu$  and a diameter of  $12\text{--}14\ \mu$ , 4-spored; spores ellipsoid, unequal-sided, usually containing two oil drops,  $10\text{--}11 \times 24\text{--}27\ \mu$  (rarely a little larger), often showing faint striations; paraphyses filiform, slightly enlarged above.

On decaying leaves of some palm, El Yunque, also on rotten wood, same locality.

The type was collected December, 1912, by J. R. Johnston and listed by Stevenson in his checklist without description. A second collection was made by the writer on old sticks, February 25, 1923, in the same locality. The hairs in this species are not conspicuous and the spore striations are faint, their prominence probably depending on the maturity of the spores.

***Humaria phyllogena* sp. nov.**

Apothecia sessile or subsessile, discoid or with the margin slightly elevated, reaching a diameter of 3–5 mm., flesh-red, brighter when dry; asci clavate, operculate, reaching a length of  $200\ \mu$  and a diameter of  $12\ \mu$ ; spores broad-ellipsoid,  $12 \times 18\text{--}20\ \mu$ , usually containing two oil drops, smooth.

On dead leaves, El Yunque, Feb. 23–26, 1923.

This suggests the genus *Cookeina* but it differs in the absence of hairs and the nonstriated spores.

**HUMARIA LEUCOLOMA** (Hedw.) Quél. Ench. Fung. 289. 1886.

*Octospora leucoloma* Hedw. Descr. 2: 13. 1788.

Two collections of plants referable to this species were made on mossy banks in the vicinity of Indiera Baja at an elevation of 800–900 M. The plants occurred in abundance and were quite characteristic except for slight variations in spore measurements.

***Humaria Cookeina* sp. nov.**

Apothecia short stipitate or subsessile with the hymenium slightly concave, reaching a diameter of 2–3 mm., bright orange, a little paler outside, the stem slightly grooved or furrowed; asci clavate, 8-spored,  $14\text{--}15 \times 160\ \mu$ ; spores partially 2-seriate, fusoid,  $30 \times 6\ \mu$ .

On decaying sticks, El Yunque, Feb. 25, 1924.

The species has the appearance of a *Cookeina* but seems to be devoid of hairs and the spores if striate are so faintly so as to leave the matter in doubt. A very scant collection was made and

further collections may give additional information on these points.

LAMPROSPORA DISCOIDEA (P. Henn. & E. Nym.) Seaver, Mycologia 6: 19. 1914.

*Barlaea discoidea* P. Henn. & E. Nym. Monsunia 1: 33. 1900.

One collection was made near Rio Piedras on the ground where cows had stepped. The plants were whitish and spores rather small, being 12-14  $\mu$  in diameter.

**Lamprospora salmonicolor** sp. nov.

Apothecia discoid with the hymenium plane or slightly convex, reaching a diameter of 2 mm., pale salmon-colored; asci cylindric or subcylindric, reaching a length of 275  $\mu$  and a diameter of 20-24  $\mu$ ; spores globose, filled with minute granules, 20  $\mu$  in diameter when mature; paraphyses clavate, reaching a diameter at their apices.

On bare ground, El Yunque, Feb. 23, 1923. Specimens abundant, differing from the preceding in the color and size of the spores.

? LAMPROSPORA WRIGHTII (Berk. & Curt.) Seaver, Mycologia 6: 15, 1914.

*Peziza Wrightii* Berk. & Curt.; Berk. & Br. Ann. Mag. Nat. Hist. III. 15: 444. 1865.

One specimen collected in the garden at the Experiment Station in Rio Piedras. The spores are subglobose.

LACHNEA COPRINARIA (Cooke) Phill. Brit. Discom. 224. 1887.

*Peziza coprinaria* Cooke, Grevillea 4: 91. 1875.

Collected on dung in the vicinity of Indiera Baja. Common but apparently not previously known from Porto Rico.

PEZIZA ADNATA Berk. & Curt.; Berk. Jour. Linn. Soc. 10: 365. 1868.

Several specimens were collected on rotten wood which seem to conform with the description of this species. The hymenium was chocolate brown and the apothecia partially adherent to the substratum but with the margin free.

a length of 1 mm., smooth or faintly striated; asci clavate, reaching a length of 100  $\mu$ , 8-spored; spores ellipsoid or with the ends slightly attenuated, usually 3-septate, and slightly constricted at the middle septum, with one longitudinal septum extending through the two central cells, pale to dark brown, 20 x 8  $\mu$ .

On twigs of *Pithecellobium Unguis-cati* (L.) Mart.

***Ionomidotis portoricensis* sp. nov.**

Apothecia cespitose, sessile or subsessile, reaching a diameter of 5–8 mm., irregular in outline from crowding, externally light brown, minutely furfuraceous and wrinkled when dry, the hymenium darker, almost black; asci clavate, 30 x 5  $\mu$ , 8-spored; spores ellipsoid, 2 x 4–6  $\mu$ ; paraphyses slightly enlarged upwards.

On dead wood, Porto Rico.

***Phialea Cecropiae* (P. Henn.) comb. nov.**

*Helotium Cecropiae* P. Henn. Hedwigia 41: 25. 1902.

Plants referable to this species originally described from southern Brasil were abundant on the fallen leaf sheaths of *Cecropia*. Several collections were made.

***Phialea microspora* sp. nov.**

Apothecia gregarious, stipitate or subsessile, not exceeding 1 mm. in diameter, the hymenium slightly concave and dull yellow, externally a little darker and clothed with clusters of cells, which approach rudimentary hairs, scarcely reaching a diameter of 1  $\mu$ ; asci clavate, about 30 x 4  $\mu$ , 8-spored; spores very small, about 6 x 1.5–2  $\mu$ .

On the upper side of leaves of unidentified host, Rio Piedras, Feb. 28, 1923; also on herbaceous stems. Apparently closely related to *Helotium phlebophorum* Pat.

NEW YORK BOTANICAL GARDEN.

# MODES OF INFECTION OF SORGHUMS BY LOOSE KERNEL SMUT<sup>1</sup>

JAMES A. FARIS AND GEORGE M. REED

(WITH PLATES 5-7)

## MODES OF INFECTION IN CEREAL SMUTS

The various species of cereal smuts differ in certain essential points in the mode of entrance into their respective hosts. The most common method seems to be the penetration of the young seedling by means of germ tubes arising from conidia, which, in turn, originate from the chlamydospores present on the seed or in the soil. Following penetration the fungus develops its mycelium in the embryonic tissue of the host. As the latter reaches its later stages of development the growth of the mycelium becomes particularly vigorous and forms a large mass of chlamydospores. We thus have a systemic development of the mycelium of the fungus in the host. This type of seedling infection occurs in several of the cereal smuts: *Tilletia laevis* Kühn, *T. Tritici* (Bjerk.) Wint., and *Urocystis Tritici* Kcke. on wheat; *Urocystis occulta* (Wallr.) Rab. on rye; *Ustilago Avenae* (Pers.) Jens. and *U. levis* (K. & S.) Magn. on oats; *Ustilago Hordei* (Pers.) K. & S. on barley; *Sphacelotheca cruenta* (Kühn) Potter, *S. Sorghi* (Link) Clint., and *Sorosporium Reilianum* (Kühn) McAlpine on sorghum. In some cases the spores are formed in the stems and later leaves. Wheat plants infected by *Urocystis Tritici* are very greatly stunted and commonly are prevented from heading, or if an infected plant does head, very little seed is produced. The fungus attains its greatest development in the leaves and to some extent in the stems. Long blackish lines appear between the veins of the leaves, due to the formation of the spores in linear masses. These later rupture and the spores escape. The effects of *Urocystis occulta* on rye are somewhat similar. The infected plants, however, more fre-

<sup>1</sup> Brooklyn Botanic Garden Contributions No. 44.

quently head out, although usually no grain is produced. The spores are formed in linear sori on the leaves and stem. The formation of sori on leaves also may occur in other smuts, as in *Ustilago Avenae* and *U. levis* on oats and *U. Hordei* on barley. However, in most of the other cereal smuts just mentioned the formation of spores takes place principally in the ovaries, although the adjacent tissues of the enclosing glumes may also be invaded. In the head smut of sorghum the entire panicle is commonly involved.

The second method of penetration is by means of germ tubes which arise directly from the chlamydospores and infect the young ovaries of the flowers. The loose smuts of wheat (*Ustilago Tritici* (Pers.) Jens.) and of barley (*U. nuda* (Jens.) K. & S.) illustrate this type of penetration, known as "flower" or "blossom" infection. In the matured seed there is present the dormant mycelium which renews its growth when the seed germinates. The mycelium occurs throughout the embryonic tissue of the developing host. When the latter begins to form its flowers, the fungus develops very rapidly and in place of the normal seed and adjacent tissues the smut spores are formed. In this case also we have a general systemic infection. The penetration of the host, however, occurs at the blossoming period by means of spores which are carried to the stigmas.

A third method, known as "local infection," occurs in the common corn smut (*Ustilago Zeae* (Beckm.) Ung.) in which any embryonic tissue of the roots, stems, leaves or flowers may be penetrated by the germ tubes which arise from conidia, produced by the germination of the chlamydospores. The fungus requires only a short time to complete its development, forming localized mycelium which, in two to three weeks, produces ripe spores. The cycle of development may be repeated several times during the growing season of the crop.

A fourth method known as "shoot infection" has been described by Hecke (5). Hecke cut back in the autumn to the ground level the shoots of the perennial *Secale montanum* and heavily inoculated the crown of the plants with the spores of *Urocystis occulta* (Wallr.) Rab. and then covered with manure containing spores. In the following year new shoots of the host

developed and these were found to be infected by the smut in the characteristic manner. Similar experiments were carried out on two-year-old plants of *Lychnis alba*. The plants were cut back to the ground level and the surfaces dusted with the spores of *Ustilago violacea* (Pers.) Fckl. and covered with manure mixed with spores. In a few days new shoots developed which flowered in the following year. These flowers were smutted in the characteristic fashion, the anthers containing the mature smut spores.

Zade (10) has suggested a new method of infection of oats by *Ustilago Avenae*. He found that the spores germinated readily on the stigmas of the flowers, giving rise to budding sporidia; the latter gave rise in turn to hyphae which came in contact with the inner wall of the glumes and there formed a mycelium. Zade concluded that this mycelium and the secondary sporidia which are borne on the hyphae on the inner surface of the glumes constitute the most important source of infection in oat smut. The fact, however, that high percentages of infection of hulled oats may be obtained by dusting the seed with spores indicates that seed inoculation is very effective in the production of oat smut.

#### EVIDENCE OF SEEDLING INFECTION OF SORGHUM BY *Sphacelotheca cruenta*

Hitherto the evidence has been that the mode of infection in the loose kernel smut of sorghum, *Sphacelotheca cruenta*, is a typical seedling penetration. Brefeld (1, 2) successfully produced infection by inoculating sorghum seed with the spores of this smut. He obtained as high as 72 per cent infection when he inoculated the germinated seed at the time that the growing point was just emerging from the seed coat. The percentages of infection greatly decreased if the plumules were 1 to 2 cm. long at the time of inoculation, and, further, if the first leaf had pushed through the sheath as much as 1 cm. no infection was obtained. Brefeld also tried to infect sorghum plants 5 in. to 2 ft. in height by pouring cultures of conidia into the cornucopia formed by the leaves, a method which proved very successful in the case of corn smut. He observed that the very young leaves of the sorghum shriveled, became quite pale and gave every evidence of the



development of mycelium in their tissues. Later, however, normal leaves appeared and the plants finally attained their usual appearance. No smut spores developed in the ovaries or any other part of the plant.

Brefeld and Falck (4), following their studies on the life history of the loose smuts of wheat and barley, raised the question as to whether flower infection might not occur in the case of *Sphacelotheca cruenta*. They inoculated flowers of sorghum at the blooming period but did not succeed in determining whether blossom infection took place, since they were unable to get the sorghums to develop to maturity in their locality and produce ripe grain. Brefeld (3), in a later paper, again suggested the possibility but was unable to demonstrate it.

Potter (7) obtained the infection of a few varieties of sorghum by inoculating the seed with the chlamydospores of *Sphacelotheca cruenta*. He further found that the formaldehyde method of seed treatment was effective in preventing loose kernel smut. Kulkarni (6) also succeeded in producing the infection of sorghums by loose kernel smut by inoculating the seed with spores. He also demonstrated the effectiveness of seed treatment when inoculated seed was treated with a two per cent solution of copper sulphate for ten minutes. Reed (8) has inoculated the seed of a large number of varieties of sorghum with the dry spores of loose kernel smut and has obtained infection in a very large number. The percentages of infection varied greatly, depending upon the variety. The highest percentage was obtained with Darso, 65 per cent of the plants being infected. Reed and Faris (9) also were successful in securing the infection of certain varieties of sorghums by the method of inoculating the dry seed with the dry spores.

All this evidence points to the fact that the successful penetration of *Sphacelotheca cruenta* into susceptible varieties of sorghums takes place in young seedlings by means of hyphae which originate from conidia, which in turn develop from chlamydospores present on the seed. It is possible that infection may also take place from spores found in the soil, but at present there is no evidence that this commonly occurs in this smut.

Reed (8) has summarized the striking pathological effects of

*Sphacelotheca cruenta* on its hosts. One of the most obvious features was observed in connection with the date of emergence of heads on infected and on normal plants. As a rule the infected plants headed out very much earlier than the normal. In fact, practically all of the heads of the smutted plants had fully emerged before any normal heads had appeared. Associated with this early emergence there were marked differences in the height of the infected plants as compared with the normal. The first to head out were only a few inches high. They usually had only two or three internodes, as compared with ten or twelve on the normal plant. The later ones to head, however, were practically as tall as the normal. However, the average for the normal and infected plants for nearly all varieties showed a marked decrease in the height of the infected. A still further point was observed in connection with the extent of tillering. An excessive number of tillers usually arose at the ground level and there was frequently an extensive development of side branches on the main stem. Consequently, young smutted heads continued to appear from lateral branches during the growing season. This extensive tillering and branching was more marked in the plants that headed out early as compared with those that headed out late.

#### A NEW MODE OF INFECTION OF SORGHUM BY *Sphacelotheca cruenta*

*Sphacelotheca cruenta* was first grown at the Brooklyn Botanic Garden in 1922 in a series of experiments designed to determine the resistance of sorghum varieties to this smut. These results are described elsewhere (8). The first experiments were started on May 23d, when the seed of several varieties of sorghums was inoculated with the spores and sown in the field. Many of these varieties proved to be susceptible and a considerable number of smutted plants with the characteristic symptoms were produced. The sori on these infected heads soon broke open and permitted the wide distribution of the spores in the field.

*Field Observations.*—Late in the season of 1922 some unusual cases of infection were noted on sorghum plants that had not previously been inoculated with the spores of loose kernel smut.

Individual plants which developed in the normal fashion and produced sound terminal heads late in the season produced lateral heads which were infected by the loose kernel smut. In none of these cases was there any dwarfing or excessive tillering of the plants. They thus differed from those that were infected by seed inoculation. These peculiar cases were especially observed in Valley Kaoliang, which was growing several rods away from the plot where the seed inoculated with *Sphacelotheca cruenta* was sown. This variety produced a number of branches from the upper nodes, perhaps due in part at least to the destruction of the grain by birds. The lateral heads infected with loose smut arose from the various nodes on the plant (Plate 5). Usually these terminal heads on the lateral branches were completely smutted but in a few cases partially smutted panicles were observed. In one case the terminal head of a plant, the seed of which had been inoculated with spores of *S. Sorghi*, was infected with the covered smut but from the third node from the top a branch originated which produced a head some of whose flowers were normal, some infected with *S. Sorghi* and others with *S. cruenta*.

It might be thought that the appearance of these lateral infected heads on plants with normal terminal ones was due to the fact that the smut, which had penetrated the seedlings, had failed to reach the terminal head but succeeded in attaining the growing point of the lateral heads. It has frequently been observed in the other smuts of cereals, oats for example, that a plant may produce normal heads followed later by smutted ones. The fact, however, that several of these infected sorghum plants appeared in the rows where the seed had not been inoculated by *Sphacelotheca cruenta* precluded this explanation. Further, the main series of experiments with sorghums in 1922, in which spores of *S. Sorghi* were used, was started in April. Several hundred seeds of different varieties were inoculated with the covered smut and germinated under controlled conditions in the constant temperature tanks in the greenhouse. They were then potted and kept in the greenhouse until May 12th to 21st when they were transplanted to the field. At the time of transplanting they ranged from approximately 6 inches to 2 feet in height. The plants in this series of experiments had no opportunity to

become inoculated by *S. cruenta* before they were transplanted to the field, since no spores of this fungus had ever been used in previous experiments at the Botanic Garden and there was no chance for the seed to become inoculated in threshing. Furthermore, the loose kernel smut was not used in or about the laboratory until May 23, several weeks after these experiments had been begun. It may also be well to emphasize the fact that no cases of typical systemic infection of *S. cruenta* occurred anywhere in the plot except where the seed had been inoculated with the spores of this smut.

Consequently, the occurrence of these infections of lateral heads led to the supposition that some other mode of inoculation and infection than through the seedlings might occur. The plausible explanation seemed to be that the loose kernel smut spores were carried to the lateral bud of developing panicles, or the young flowers, where infection took place at once, giving rise in a few weeks to the smutted kernels. As further evidence on this point it may be pointed out that relatively large numbers of loose kernel smut spores were being distributed throughout the field, beginning in the latter part of July, about the time that normal heads of sorghums were beginning to appear in some of the early plantings. As the season progressed the number of spores being thus distributed was greatly increased. It was further found that, in general, the number of plants with normal terminal heads and lateral heads infected with loose kernel smut was greatest in the vicinity of the rows which were showing relatively high percentages of loose smut.

In 1923 extensive series of plantings of sorghums, separate lots of seed being inoculated with *Sphacelotheca Sorghi* and *S. cruenta*, were made in order to determine the temperature and moisture relations of infection. These results have been reported elsewhere (9). During this season also there were observed a number of cases where plants which grew normally and produced sound terminal heads later produced lateral heads with the usual symptoms of loose kernel smut. Careful records of these were made with special reference to their location in the plots. The number of these increased greatly as the season advanced. In other words, as the normal plants produced a larger number of

lateral branches, the number of infected ones increased and no final data regarding the total number were recorded. Such infections occurred on plants which had been inoculated with *S. Sorghi* as well as with *S. cruenta*. It may be emphasized, however, that no cases of characteristic systemic infection of *S. cruenta* occurred in any row except where the seed had been inoculated with the loose kernel smut. There was no evidence of any chance contamination of seed by this smut.

Only a few varieties of sorghum were grown in 1923 and the appearance of the infected laterals was again especially noted in Valley Kaoliang. However, other cases of special interest also were observed. On some terminal heads of Darsó, Blackhull Kafir and Valley Kaoliang a few individual kernels were found to be infected. As a rule all the flowers of the panicles are destroyed by the loose kernel smut. In the cases just mentioned, however, a small number of flowers were attacked and the appearance of the smut balls differed somewhat from the usual type, the special peculiarities of which are described below.

The facts observed gave strong support to the idea that a hitherto unknown mode of infection of sorghums by loose kernel smut might occur. In order to determine whether this was the case, a number of plants of Valley Kaoliang, which showed infected lateral heads, were dug up late in the fall of 1923 and over-wintered in the greenhouse. Careful records were made on the distribution of the lateral smutted heads on these plants. In the spring of 1923 they were set out in the field and grown to maturity. The accompanying table gives a record of the 19 plants which were carried through in this manner.

During the season of 1924 all of these plants produced from three to six or more stalks of equal height and vigor. In addition, particularly early in the season, a number of short stalks were also produced. Seventeen of these plants proved to be entirely sound. No smutted panicles were observed on either the short stalks or the long. Two plants, however, Nos. 6 and 7, gave rise to a few short stalks, the heads of some of which were infected in the characteristic manner by *Sphacelotheca cruenta*. Both of these plants, however, also gave rise to strong vigorous stems, upon which sound panicles developed.

One plant of Darso which showed a few infected kernels on the terminal head also was carried through in the same fashion. This plant produced several heads in 1924 without the slightest evidence of any infection by *Sphacelotheca cruenta*.

DISTRIBUTION OF SMUTTED LATERAL PANICLES ON VALLEY KAOLIANG—1923

Plant numbers	Number of node from top of plant				
	2d	3d	4th	5th	6th
1 <sup>a</sup> , 3, 4, 12 <sup>a</sup> .....	S	—	—	—	—
2 <sup>b</sup> , 6, 9, 10, 15.....	N	S	—	—	—
5 <sup>c</sup> , 11 <sup>a</sup> .....	S	N	—	—	—
13 <sup>a</sup> , 14 <sup>a</sup> .....	—	S	—	—	—
7.....	S	S	—	—	—
8.....	N	S	N	S	—
16, 17.....	N	N	—	S	—
18.....	—	N	—	—	S
19 <sup>d</sup> .....	—	—	—	—	—

S indicates that the lateral branch bore a smutted panicle and N indicates that it bore a normal panicle.

The dash (—) indicates that no lateral branch developed from this node.

<sup>a</sup> The lateral branch produced secondary smutted heads in addition to the terminal one.

<sup>b</sup> A branch with normal head also arose from the first node.

<sup>c</sup> The head was only partially smutted.

<sup>d</sup> A few flowers near the base of the terminal head were infected. Plants 6 and 7 showed smutted branches in 1924.

These facts in general fit with the interpretation that infection occurred in the young panicle buds or in individual flowers by means of spores which were carried by the wind or other possible agents from adjacent infected plants. Apparently if the spores reached the young developing panicle in sufficient numbers and at the right stage of development, all the flowers were infected. If, however, the stage of development of the flowers was not favorable or the spores were not sufficiently numerous, only a few flowers became infected. In every case, however, the infection was localized. The mycelium apparently did not grow backwards into the stem and later attain the embryonic tissues of other panicles. It is probable that the panicles on the two plants which showed infection in 1924 had become inoculated during the period of their embryonic development and that a characteristic local infection occurred.

*Greenhouse Inoculation Experiments.*—In order to definitely determine whether a secondary local infection of the panicles or individual flowers, as distinct from a general systemic infection through seedlings, can be produced in sorghums by *Sphacelotheca cruenta*, a series of experiments was carried out under controlled conditions. Five varieties of sorghum were planted in pots in the greenhouse April 19, 1924. The seed used was smut free and the plants had no opportunity to become accidentally inoculated. On August 27 some of the plants had produced terminal heads, all of which were sound. These terminal heads were removed and inoculations were made by injecting spores of *S. cruenta* into either the boot, into the growing point, or between the leaf sheath and internode, as indicated in the following description of the various plants. The spore material used was secured from newly smutted heads in the field just as they began to appear. The smut balls were broken up and dusted into a beaker of tap water. The spore suspension thus obtained was injected into the sorghum plants with a hypodermic needle. The details for each plant are recorded below:

VALLEY KAOLIANG (S.N. 192). Ten plants.

*Plant No. 1.* Terminal head sound, removed, and the first lateral branch injected at the base of the cornucopia. Marked lesions upon the new unfolding leaves appeared within a few days.

*Results: Oct. 1.* First and second panicles on lateral branch completely smutted.

*Oct. 14.* Two uninoculated tillers remained sound.

*Plant No. 2.* Terminal head inoculated by injecting the growing point at base of cornucopia with a suspension of spores just before the head began to swell.

*Result: Oct. 14.* Head partially smutted (Pl. 6, Fig. 1). Two uninoculated lateral branches remained sound.

*Plant No. 4.* Terminal head sound and removed when a lateral branch was inoculated at top of cornucopia.

*Result: Oct. 7.* No infection.

*Plant No. 5.* Terminal head sound and removed when a lateral branch was inoculated at base of the cornucopia.

*Result: Oct. 7.* No infection.

*Plant No. 7.* Terminal head sound and removed when two lateral branches (*a*) and (*b*) and the first and second tillers were inoculated near the growing points.

*Results: Sept. 29.* A lateral panicle on branch (*a*) completely smutted, and some kernels on the terminal panicle of branch (*b*) smutted.

*Oct. 7.* The terminal head on branch (*a*) completely smutted.

*Oct. 14.* The two tillers headed. No infection.

*Plant No. 8.* Terminal head sound and removed when a lateral branch was inoculated at growing point.

*Results: Sept. 29.* Head of the lateral branch completely smutted.

*Oct. 1.* Two lateral heads on the lateral branch also completely smutted.

*Plant No. 10.* Terminal panicle sound and removed when two lateral branches (*a*) and (*b*) were inoculated at the growing point.

*Results: Sept. 20.* Terminal panicle on branch (*a*) smutted.

*Oct. 7.* No infection of panicle on branch (*b*).

*Oct. 14.* A lateral panicle on branch (*a*) completely smutted.

*Plants No. 3, 6 and 9. Checks. October 14.* No infection in any.

BLACKHULL KAFIR (S.N. 223). Six plants.

*Plant No. 1.* "Boot" filled with inoculum just as the apex of the head was about to emerge.

*Result: Oct. 14.* Head partially smutted. Two lateral branches not inoculated—no infection.

*Plant No. 2.* "Boot" filled with inoculum when the head was about one half the length of the top leaf sheath.

*Result: Oct. 14.* Head partially smutted (Pl. 6, Fig. 2). Two lateral branches not inoculated—no infection.

*Plant No. 4.* "Boot" filled with inoculum when the head development was between the stages of plants No. 1 and No. 2.

*Results: Sept. 20.* Many kernels of terminal head smutted.

*Oct. 14.* Lateral branch not inoculated—no infection.

*Plant No. 5.* "Boot" filled with inoculum when the head was about the stage of development of plant No. 2.

*Result: Sept. 25.* Lower part of head blighted. Some kernels smutted.

*Plants No. 3 and 6. Checks. Oct. 14.* No infection.



DARSO (S.N. 225). Six plants.

*Plant No. 1.* "Boot" filled with inoculum just as the head was beginning to enlarge.

*Results: Sept. 20.* Many smutted kernels (Pl. 6, Fig. 3).

*Oct. 14.* Two lateral branches not inoculated. No infection.

*Plant No. 2.* "Boot" filled with inoculum just as the head began to break through the last leaf sheath.

*Results: Sept. 20.* Partially smutted head.

*Oct. 14.* One lateral branch not inoculated—no infection.

*Plant No. 4.* "Boot" filled with inoculum just as head began to emerge. Two lateral branches injected at the base of cornucopia.

*Results: Sept. 20.* Terminal head partially smutted.

*Oct. 14.* Panicles on both lateral branches smutted. A third lateral branch and one tiller not inoculated—no infection.

*Plant No. 5.* "Boot" filled with inoculum just as the head began to emerge. One tiller injected at the growing point.

*Results: Sept. 20.* Head partially smutted.

*Oct. 7.* Tiller totally smutted.

*Plants No. 3 and 6. Checks. Oct. 14.* No infection.

RED AMBER SORGO (S.N. 232). Six plants.

*Plant No. 1.* Inoculated just as head was about to emerge from the "boot." Two tillers injected at base of cornucopia.

*Results: Sept. 20.* Terminal head partially smutted.

*Oct. 14.* Both tillers sound.

*Plant No. 2.* Terminal head inoculated at about the same stage of development as the terminal head of plant No. 1.

*Result: Sept. 20.* Partially smutted.

*Plant No. 4.* Terminal head sound and removed when two lateral branches (a) and (b) were injected at the base of the cornucopia.

*Results: Sept. 22.* Terminal panicle on branch (a) partially smutted.

*Oct. 1.* Much distortion and lateral branch (b) killed. A secondary branch on branch (b) smutted.

*Oct. 14.* A second lateral panicle on branch (a) completely smutted.

*Plant No. 5.* Terminal head injected at base of the cornucopia.

*Results: Sept. 12.* Head blasted and failed to develop. Three lateral branches inoculated by putting spores under leaf sheath.

*Sept. 29.* Two lateral branches completely smutted. The third blasted and did not develop.

*Plants No. 3 and 6. Checks. Oct. 14.* No infection.

SORGHUM FROM INDIA (S.N. 263). Four plants.

*Plant No. 1.* Terminal head injected at the base of the cornucopia.

*Result: Oct. 14.* No infection.

*Plant No. 2.* Terminal head injected at the base of the cornucopia.

*Result: Oct. 14.* No infection.

*Plant No. 3. Check. Oct. 14.* No infection.

*Plant No. 4.* Terminal head injected at the base of the cornucopia.

*Result: Oct. 14.* Kernels of the lower two thirds of the head were smutted and had the appearance of kernels of plants infected in the seedling stages. A head on a lateral branch completely smutted.

Of the ten plants of Valley Kaoliang six attempts at artificial inoculation resulted in infection, while four failed to develop smut. All trials with Blackhull Kafir and Darso were successful, while six inoculated heads of Red Amber Sorgo were infected, two were so blasted that they did not develop and two failed. In the three attempts to cause infection in the sorghum from India two failed and one was successful. In all, twenty-five infected heads resulted from thirty-three inoculations. Since the failures were with young stalks where the exact location of the growing point is difficult to determine, it is quite likely that a series of injections along the stem in that region would insure complete success.

When the infection takes place in individual ovaries in relatively late stages of flower formation, the smutted kernels are often greatly developed on one side (Pl. 7, Figs. 1-4). All stages from slightly smutted seed, where there is a relatively small amount of diseased tissue, to a complete smutting of the kernel have been observed. The extent of the diseased tissue in such cases seems to depend largely upon the stage of development of the kernel before the smut mycelium gained entrance.

## DISCUSSION AND CONCLUSIONS

The experiments described clearly establish the fact that a hitherto unknown type of infection of sorghums by *Sphacelotheca cruenta* actually occurs. In addition to the general systemic infection, which results from the penetration of seedlings by germ tubes, we have a distinct local infection in which individual flowers, parts of panicles, or frequently entire panicles, are involved. The extent of this local infection evidently depends upon whether the smut spores reach the embryonic tissues in sufficient numbers at the proper stage of development. As already noted, systemic infection results in the production of characteristic pathological symptoms—the excessive dwarfing, tillering, production of heads, etc. Quite regularly all the panicles on such a plant are infected. In this new type of infection no general development of mycelium occurs in the host and the pathological symptoms just described are lacking. The growth of the mycelium is confined to the individual part—flower, panicle or branch—which is invaded. If this branch is removed, the plant will continue to produce only sound stems and panicles.

This local type of infection bears many resemblances to the conditions found in corn smut. In the latter, however, any embryonic tissue may be invaded and the mycelium appears to be strictly local in its cycle of development. The mycelium may develop in the tissues of roots, stems, leaves, ovaries and stamens, causing hypertrophy and later giving rise to spores. In our experiments, the formation of smut spores occurred only in the flowers of the sorghum, although the production of sori on the pedicels has been described.

There also are resemblances between this type of infection in sorghum and the "shoot infection" described by Hecke (5). As already noted, the latter was able to secure the infection of the young buds of *Secale montanum* by the spores of *Urocystis occulta*. The shoots which resulted from these buds gave rise to the characteristic pathological symptoms of the smut. The same thing occurred in young shoots of *Lychnis alba* when inoculated with the spores of *Ustilago violacea*. In our experiments the infection appeared to be confined to smaller portions of the shoot system. It is possible, however, that if injections were made in

still earlier stages, larger portions of the resulting shoots would be involved.

It is interesting to consider why Brefeld (1, 2) failed to obtain smutted panicles in his experiments in which he poured conidia into the cornucopia of sorghum plants 5 inches to 2 feet high. The probable explanation is that the conidia were unable to reach the embryonic bud of the plant. The young leaves on the stem of sorghum are so arranged that spores poured in would be prevented from actually reaching the growing point.

The modes of infection of sorghums by *Sphacelotheca cruenta* are quite varied. We have not only the general systemic infection through seedlings but also local types of infection as well as a type of shoot infection. A further interesting question arises, whether we have a blossom infection such as occurs in the loose smut of wheat and barley. Brefeld and Falck (4) were unable to obtain any evidence on this point. Our own experiments have not been carried out sufficiently to determine whether a typical blossom infection occurs.

Since plants infected in the seedling stage by *Sphacelotheca cruenta* head out prematurely and consequently the spores are readily distributed, the question may be raised as to how the spores get in contact with the ripe seed, and thus be carried over to the next planting season. Undoubtedly the greatest number of spores produced are distributed far and wide and do not come in contact with ripe grain. A considerable proportion, however, remain in the smutted head and if the latter is gathered and threshed with the sound heads the kernels may be contaminated.

The premature heading of these infected plants, however, also makes it possible for the spores produced in such heads to be carried to the immature panicles and lateral buds of neighboring plants. Our experiments and field observations have demonstrated that a considerable percentage of plants inoculated in this way may develop loose smut in individual kernels or throughout the entire head. This mode of infection occurred in our experiments under conditions comparable to field plantings of contaminated seed. When a few individual kernels of an otherwise sound head are smutted, the spores from these are likely to be spread over the adjacent normal grains and the chances that the fungus

will be carried to the succeeding crop are increased. No doubt this mode of infection may be responsible for some of the losses due to the loose kernel smut but its economic importance can be determined only by extensive field experiments.

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#### EXPLANATION OF PLATES

##### PLATE 5

Secondary infection of Valley Kaoliang (S.N. 192) by *Sphacelotheca cruenta* in the field.

Fig. 1. Terminal head normal; smutted panicles on lateral branches from second and fourth nodes from the top of the plant; normal panicle on lateral branch from third node.

Fig. 2. Terminal head normal; smutted panicle on lateral branch from third node.

Fig. 3. Terminal head normal; normal panicle on lateral from second node; smutted panicles from third and fourth nodes.

##### PLATE 6

Secondary infection of sorghums by *Sphacelotheca cruenta* experimentally produced. In each case a number of flowers have become infected and given rise to the smut balls. The normal kernels are still small and inconspicuous.

Fig. 1. Valley Kaoliang (S.N. 192).

Fig. 2. Blackhull Kafir (S.N. 223).

Fig. 3. Darso (S.N. 225).

PLATE 7

Secondary infection of sorghums by *Sphacelotheca cruenta* experimentally produced.

Figs. 1, 3. Enlarged ( $1\frac{1}{2}$  times) smut balls on Blackhull Kafir (S.N. 223).

Figs. 2, 4. Enlarged ( $1\frac{1}{2}$  times) smut balls on Valley Kaoliang (S.N. 192).

## NEW SPECIES OF FUNGI<sup>1</sup>

G. BRESADOLA

### *Corticium apiculatum* Bres. n. sp.

Late effusum, membranaceum, cremeum, margine albo, subfimbriato, hymenio laeve, demum laxe areolato-diffracto; sporis oblongis, valde apiculatis, hyalinis,  $5-6 \times 3 \mu$ ; basidiis clavatis,  $40-45 \times 7-8 \mu$ ; hyphis tenuibus, septatis, saepe ad septa nodosis,  $4-7\frac{1}{2} \mu$ .

Hab. ad truncos *Alni tenuifoliae*, Idaho. (Weir 23304.)

Obs. Habitu *Corticio laevi* valde simile, sed sporis et structura diversum.

### *Corticium areolatum* Bres. n. sp.

Late effusum, subceraceum, arcte adnatum ex albo subalutaceum, margine pruinato; hymenio dense areolato-diffracto; sporis hyalinis, subellipticis, uno latere depressis,  $7-9 \times 4-5 \mu$ ; basidiis clavatis,  $24-25 \times 6-7 \mu$ ; hyphis irregularibus, septato-nodosis,  $1\frac{1}{2}-3 \mu$ , cystidiis nullis.

Hab. ad ramos *Alni tenuifoliae*, Idaho. (Weir 23387.)

Obs. Von Aussehen scheint ganz *Corticium scutellare* Berk. et C., aber dieser nach Ex. aus America ist eine *Peniophora* mit kleineren Sporen und grösseren Hyphen.

### *Corticium consimile* Bres. n. sp.

Late effusum, tenue, pelliculare, ex albo flavidulum, margine subsimilare; hymenio laevi, haud rimoso; sporis hyalinis,  $4-4\frac{1}{2} \times 2-2\frac{1}{2} \mu$ ; basidiis clavatis,  $15 \times 4 \mu$ ; hyphis tenuibus, septatis, vix nodosis,  $2\frac{1}{2}-4$ , aliqua inflata  $6 \mu$ .

Hab. ad truncos decorticatos *Laricis occidentalis*, Idaho. (Weir 10808.)

Obs. Von *Corticium decipiens* v. Höhn. et Litsch. durch kleinere Sporen und unregelmässigen Hyphen verschieden.

<sup>1</sup> This paper was sent to me by the author for publication. The descriptions of the new species are based on material in my herbarium and are the result of an extended correspondence and exchange of specimens with G. Bresadola.—JAMES R. WEIR.

**Corticium furfuraceum** Bres. n. sp.

Latissime effusum, vix 100–150  $\mu$  crassum, furfuraceum, pallidum, demum subalutaceum, margine pruinato; hymenio fatisciente; sporis hyalinis, 4–6 x 2½–3  $\mu$ ; basidiis 8–10 x 4–5  $\mu$ ; hyphis conglutinatis, indistinctis.

Hab. ad ligna *Thujae plicatae*, *Abietis grandis*, *Laricis occidentalis*, *Pini monticolae*, Idaho. (Weir 17211, 16764, 16927.)

Obs. Aussehen fast von *Corticium botryosum* Bres. aber Struktur und Sporen ganz verschieden.

**Corticium subapiculatum** Bres. n. sp.

Late effusum, arcte adnatum, ceraceum, ex alutaceo fulvescente, margine albo, pruinato; hymenio laevi, haud rimoso; sporis hyalinis, oblongis, breviter apiculatis, 6–7 x 3–3½  $\mu$ ; basidiis clavatis, 25–26 x 4–6  $\mu$ ; hyphis tenuibus, septato-nodosis, 3–4½ raro 6  $\mu$ .

Hab. ad truncos *Pini*, Idaho. (Weir 16928.)

Obs. Dem *Corticium confluens* Fr. sehr verwandt, aber gut verschieden.

**GLOEOCYSTIDIUM POLYGONIUM** (Pers.) var. *fulvescens* Bres. n. var.

Orbiculare, dein confluens et late effusum, arcte adnatum, fulvellum, margine subfimbriato, albo; hymenio laevi, applanato; sporis cylindraceo-curvulis, hyalinis, 6–9 x 2½–3  $\mu$ ; basidiis 30–35 x 6–8  $\mu$ ; gloeocystidiis immersis, clavato-subcapitatis, flavis, 36–40 x 24–28  $\mu$ ; hyphis irregularibus, flexuosis, 4–5  $\mu$  crassis.

Hab. ad corticem *Populi trichocarpae*, Idaho. (Weir 16824, 14561.)

Obs. Von Type durch Form und Farbe ganz verschieden. Nur die mikroskopische Merkmalen sind gleich.

**Peniophora albo-straminea** Bres. n. sp.

Orbicularis, dein confluens et late effusa, tenuis, subceracea, ex albo straminea, margine pruinato; hymenio laevi, rimoso; sporis ellipticis, hyalinis, 6–7½ x 4–4½  $\mu$ ; basidiis clavatis, 24–25 x 6–8  $\mu$ ; cystidiis clavatis, laevibus, 80–105 x 6–9  $\mu$ ; hyphis conglutinatis, irregularibus, 1½–6  $\mu$ .

Hab. ad corticem *Alni tenuifoliae*, Idaho. (Weir 17069, 16818.)

Obs. Dem *Peniophora crenea* verwandt, aber durch Sporen und Struktur ganz verschieden.



**Peniophora gilvidula** Bres. n. sp.

Latissime effusa, arcte adnata, ceracea, gilvidula, margine e pruinato similari; hymenio laevi, aetate hic illic rimoso; sporis hyalinis, 1-guttulatis,  $6-7 \times 3-4 \mu$ ; basidiis clavatis,  $30-35 \times 6 \mu$ ; cystidiis subfusoides,  $120-150 \times 6-8 \mu$ , laxe granuloso-scabris; hyphis indistinctis, aliqua visa  $3-4$ , tenuibus.

Hab. ad ligna *Pini ponderosae*, Montana. (Weir 23305.)

Obs. In der Nähe von *Peniophora albostraminea*.

**Peniophora lepida** Bres. n. sp.

Late effusa, ceraceo-membranacea,  $\frac{1}{2}$  mm. crassa, isabellina, margine demum libero, revoluto; hymenio laevi, pulverulento; sporis non inventis; basidiis  $45-50 \times 8-9 \mu$ ; cystidiis  $70-90 \times 7-9 \mu$ ; hyphis septato-nodosis,  $2-4\frac{1}{2} \mu$ .

Hab. ad truncos emortuos *Salicis* sp., Idaho. (Weir 16744, 15003.)

Obs. Scheint *Corticium lepidum* Romell, aber Struktur verschieden.

**Peniophora rhodochroa** Bres. n. sp.

Late effusa, ceraceo-membranacea, subiculo albo, tenui, tomentoso, margine fimbriato, hymenio laevi, *turide roseo*; sporis hyalinis, 1-guttulatis, oblongis,  $6-6\frac{1}{2} \times 3-3\frac{1}{2} \mu$ ; basidiis clavatis,  $26-28 \times 6-7 \mu$ ; cystidiis fusoides vel clavatis, granuloso-obtectis,  $60-75 \times 7-9 \mu$ ; hyphis tenuibus, septatis, ad septa interdum nodosis,  $4-10 \mu$  crassis.

Hab. ad ramos *Alni tenuifoliae*, Idaho. (Weir 16809.)

Obs. Der *Peniophora lepidae* verwandt.

**Peniophora (Gloeopeniophora) Weiri** Bres. n. sp.

Latissime effusa, arcte adnata, tenuis, subceracea, ochroleuca, margine similari; hymenio laevi, interrupte rimoso; sporis subellipsoideis vel piriformibus, hyalinis,  $7-9 \times 3-4 \mu$ ; basidiis clavatis,  $24-25 \times 6-7 \mu$ ; cystidiis subcylindratis v. apice capitatis, laevibus,  $80-110 \times 4-7 \mu$ ; gloeocystidiis immersis, succo luteo repletis,  $50-60 \times 6-7 \mu$ ; hyphis tenuibus, irregularibus, septatis, interdum ad septa nodosis,  $3-6 \mu$  crassis.

Hab. ad truncos *Pini monticolae*, Idaho. (Weir 23345.)

Obs. Von Aussehen scheint *Corticium ochraceum* Fr. aber die Struktur ganz verschieden.

**Aleurodiscus helveolus** Bres. n. sp.

Erumpens, pulvinatus, rugulosus, ceraceus, helveolus, 2–3 mm. latus, ex hyphis tenuibus, irregularibus, septatis, interdum ad septa nodosis, 3–10  $\mu$  latis, conflatus; sporis hyalinis, obovato-oblongis, 18–21 x 6–9  $\mu$ ; basidiis 2–4 sterigmatibus, 80–100 x 7–9  $\mu$ ; paraphysibus irregularibus, undulato-restrictis, moniliformibus, laevibus, 3–6  $\mu$  crassis, apice interdum subcapitatis.

Hab. ad ramos *Salicis lasiandrae*, Washington. (Weir 16312.)

Obs. Structura hymenii ad *Aleurodiscum amorphum* accedit.

**Aleurodiscus succineus** Bres. n. sp.

Superficialis, convexus vel cupularis aut explanatus, ceraceus, succineus, expallens, 2–6 mm. longus, 2–8 mm. latus,  $\frac{1}{2}$  mm. crassus, ex hyphis irregularibus, tenuibus, septatis, vix nodosis, 2–5  $\mu$  crassis conflatus; sporis non visis; basidiis clavatis, 120–150 x 6–8  $\mu$ , adhuc immaturis, paraphysibus superne aculeolatis, 3–7  $\mu$  crassis; gloeocystidiis immersis, subfusoides, 75–100 x 8–10  $\mu$ .

Hab. ad *Arbutum Menziesii*, Oregon (Weir 8682).

Obs. *Aleurodisco croceo* Pat. videtur affinis, sed in isto de gloeocystidiis non fit sermo, nec noster erumpens, sed provsus superficialis est.

**Odontia eriozona** Bres. n. sp.

Late effusa, subiculo tomentosulo vix manifesto, margine evidenter tomentoso, albo; aculeis subulatis, distinctis vel basi 2–3 connatis, stramineis, 2–3 mm. longis; sporis obovatis, hyalinis, 4 $\frac{1}{2}$  x 2 $\frac{1}{2}$ –3  $\mu$ ; basidiis clavatis, 12–15 x 3–4  $\mu$ ; hyphis homogeneis, 1 $\frac{1}{2}$ –2 $\frac{1}{2}$   $\mu$ .

Hab. ad ramos, Alabama. (Weir 19579, 19582.)

Obs. *Odontiae stenodonti* Pers. affinis, sed subiculo, aculeis majoribus et sporis ovatis satis diversa.

**Odontia furfurella** Bres. n. sp.

Late effusa, subiculo tenui, albo, crustaceo-furfureo, margine similari; aculeis distinctis, ex albo stramineis, parvis, fere papilliformibus, apice plumulosis; sporis cylindraceo-curvulis, biguttulatis, 4–5 x 1–1 $\frac{1}{2}$   $\mu$ ; basidiis 9–12 x 3–4  $\mu$ ; hyphis conglomeratis, septato-nodosis, 2–3  $\mu$ .

Hab. ad ramos *Pini virginianae*, Virginia. (Weir 20064, 20087.)

Obs. *Odontiae farinaceae* Pers. affinis, sed subiculo magis crustaceo et sporis prorsum diversis bene distincta.

**Hydnum beneolens** Bres. n. sp.

Caespitosum, ex albo cremeum vel ochraceum; pileolis numerosis, carnosio-fibrosis, imbricatis, spathulatis vel flabelliformibus, glabris, azonis, 2–18 cm. latis, 2–12 cm. longis, basi in corpus crassum vel stipitiformem coalitis; aculeis variabilibus, subulatis vel spathulatis aut lamelloso-conjunctis, in stipitem decurrentibus, caro alba, immutabilis, odore grato, amygdalino, sapore miti; sporis hyalinis, globosis vel subglobosis,  $6-7\frac{1}{2} \times 5-6 \mu$ ; basidiis clavatis,  $20-25 \times 4-6 \mu$ ; hyphis hymenii conglutinatis,  $2-6 \mu$ ; toto planta generatim globosa, 10–30 cm. diam.

Hab. ad truncos, Chile. (*M. R. Espinosa 30, Weir 16363.*)

Obs. *Hydno septentrionali* proximum, sed minor, aculeis magis variabilibus et sporis diversum.

**Merulius armeniacus** Bres. n. sp.

Crustaceo-adnato, mycelio albo, hic illic roseolo, membrana subhymenina flava; plicis poriformibus, angulatis aureis, in sicco toto armeniaco; sporis hyalinis, cylindraceo-subcurvulis, biguttulatis,  $4-4\frac{1}{2} \times 1\frac{1}{2}-2 \mu$ ; basidiis subcapitatis,  $20-22 \times 4-5 \mu$ ; hyphis septatis, non nodosis, aliqua granuloso-tecta,  $2\frac{1}{2}-4\frac{1}{2}$  raro  $5 \mu$ .

Hab. ad truncos *Abietis grandis*, Idaho. (*Weir 15306.*)

Obs. *Merulio aureo* proximus, sed notis datis bene distinctus.

**Merulius interruptus** Bres. n. sp.

Resupinato-effuso, membranaceo, margine demum libero; membrana 1 mm. circiter crassa, albida; plicis interrupte manifestis; irregulariter plicoso-girosis, carneis; sporis hyalinis, cylindraceis,  $4-5 \times 2 \mu$ ; basidiis clavatis,  $24-27 \times 4-5 \mu$ ; hyphis mollibus, septato-nodosis,  $4-6 \mu$  crassis.

Hab. ad truncos *Liriodendri*, coll. *Shear 4013.* (*Weir 20743.*)

Obs. *Merulio rufo* proximus, sed membrana tenaciori, colore, modo crescendi etc. diversus.

**Ganoderma (Amauroderma) expallens** Bres. n. sp.

Pileo e castaneo pallido expallente, orbiculari vel reniformi, umbilicato, margine lobato, glabro, leniter zonato, 4–5 cm. lato; stipite centrali vel excentrico, saepe radicato, pallido, glabrescente, medullato farcto, 4–6 cm. longo, 3–5 mm. crasso; tubulis 3 mm. longis; poris concoloribus, angulatis, saepe pentagonis, 4

pro mm.; sporis stramineis, laevibus, globosis vel ellipticis, interdum inaequilateralibus,  $8-10 \times 7-9 \mu$ ; hyphis hymenii hyalinis,  $1\frac{1}{2}-3\frac{1}{2} \mu$ ; pilei  $1\frac{1}{2}-4$  raro  $4\frac{1}{2} \mu$ .

Hab. ad truncos, Uganda Africae, coll. Maitland. (*Weir 20219*.)

**Ganoderma** (*Amauroderma*) **rubeolum** Bres. n. sp.

Pileo orbiculari, glabro, plus minusve ruguloso, rubido, 3-8 cm. lato; substantia suberoso-coriacea, luride ochracea; stipite centrali vel excentrico, pruinoso, tereti vel compresso, subcavo, fuscidulo, 6-9 cm. longo, 5-6 mm. crasso; tubulis 4-5 mm. longis; poris minimis, rotundis, 6-7 pro mm. dissepimentibus obtusis, crassis; sporis pallidis, laevibus, subglobosis,  $11-12 \times 9-10 \mu$ ; hyphis hymenii pallidis vel luteis, majoribus crasse tunicatis, 3-8  $\mu$ ; pilei 3-6  $\mu$ , sinuosis, crasse tunicatis, luteis.

Hab. ad truncos, Uganda Africae, coll. Maitland. (*Weir 20217*.)

**Polyporus leucoxanthus** Bres. n. sp.

Pileo dimidiato, interdum scalarimbricato et postice resupinate producto, convexo, leniter ruguloso, pallido-alutaceo, subvelutino glabrato, 2-4 cm. lato et longo, 2-3 mm. crasso; substantia alba, coriacea-suberosa; tubulis alutaceis, 1-2 mm. longis; poris subrotundis, ex albo-concoloribus, 4-5 pro mm.; sporis hyalinis, cylindraceis, subcurvulis,  $4 \times 1\frac{1}{2}-2 \mu$ ; basidiis clavatis,  $10-12 \times 3-4 \mu$ ; hyphis hymenii homogeneis vel crassiuscule tunicatis, 2-3 $\frac{1}{2} \mu$ , pilei  $1\frac{3}{4}-4 \mu$ .

Hab. ad truncos *Robiniae pseudacaciae*, Virginia., (*Weir 21127*) et ad truncos *Populi tremulae*, Rossia, Wasilienka.

**Polystictus pallidulus** Bres. n. sp.

Pileo membranaceo, flabelliformi, pallido vel subcrustulino pallescente, e subvelutino glabrato, longitudinaliter striato ruguloso, subsulcato-zonato, 2-4 cm. lato, 2-3 cm. longo, 2-3 mm. crasso; tubulis vix 1 mm. longis; poris minimis, subrotundis, 6-7 pro mm., albo-stramineis; sporis non inventis; hyphis hymenii homogeneis,  $1\frac{1}{2}-3$ , pilei  $1-6\frac{1}{2} \mu$ , majoribus tenuibus vel crassiuscule tunicatis.

Hab. ad truncos in Brasilia (Rick) et Cuba (Hioram). (*Weir 17687, 21035*.)

Dem *Polystictus elongatus*, *P. prolificans*, etc., verwandt, aber durch Poren ganz regelmässig und ohne Cystiden sehr gut verschieden.

**Polyporus subcapucinus** Bres. n. sp.

Pileo suberoso-lignoso, dimidiato-sessili, convexo, velutino, saepe margine lobato, late zonato-sulcato, rufo-fusco, 2–4 cm. lato et longo, 3–5 mm. crasso; tubulis 2–3 mm. longis; poris parvis, subrotundatis, 5–7 pro mm., fuscis; sporis luride luteolis,  $3\frac{1}{2}$ – $4 \times 2\frac{1}{2}$ –3  $\mu$ ; hyphis hymenii 2–3 $\frac{1}{2}$ , pilei 2 $\frac{1}{2}$ –6  $\mu$ . saepe abrupte restrictis.

Hab. ad truncos, Brasiliae. (*Weir* 21026–*C. G. Lloyd* 10769.)

Dem *Polyporus capucinus* Mont. verwandt, aber von Aussehen scheint fast gleich der *Trametes scleromyces* Berk.

**Trametes cerina** Bres. n. sp.

Pileo suberoso, dimidiato, postice resupinato producto, puberulo, 2–3 cm. lato, 1 cm. circiter longo, cervino; tubulis concoloribus, 3–4 mm. longis; poris  $\frac{3}{4}$  mm. latis, subrotundis, dissepimentibus oblongis, concoloribus; sporis oblongis, hyalinis, 12–15  $\times$  5 $\frac{1}{2}$ –6  $\mu$ ; basidiis clavatis, 20–24  $\times$  5–6  $\mu$ ; hyphis hymenii 2–3  $\mu$ ; pilei 2–4 raro 4 $\frac{1}{2}$   $\mu$ , flavidis.

Hab. Cuba. (*Weir* 17749.)

Obs. *Trameti ochroflavae* proxima, sed multo minor.

**Trametes rubricosa** Bres. n. sp.

Resupinata, subiculo obsoleto, fusco-purpurea; tubulis 4–6 mm. longis; poris rotundatis vel elongatis  $\frac{1}{2}$ –1 $\frac{1}{2}$  mm. latis; sporis non inventis; basidiis 12  $\times$  4  $\mu$ ; cystidiis 18–20  $\times$  4–7  $\mu$ , apice muricellatis, dein laevibus; hyphis subhymenialibus hyalinis, tenuibus, septato-nodosis, 2–3  $\mu$ ; contextus stramineis, septatis, 2–4  $\mu$ .

Hab. ad ramos *Juniperi monospermae*, New Mexico. (*Weir* 18496, 17307.)

Der *Trametes micans* verwandt, aber durch Farbe, durch Poren viel mehr grösser und Cystidien gut verschieden.

**Trametes subcervina** Bres. n. sp.

Pileo dimidiato-sessili, saepe resupinato producto, convexo, e pubescente glabrato, luride subcervino, 2–3 cm. lato, 1–2 cm. longo, 4 $\frac{1}{2}$ –6 mm. crasso; substantia suberoso-coriacea, concolore; tubulis 3–5 mm. longis; poris subrotundis vel oblongis, 2 pro mm. vel 2  $\times$  1 mm.; sporis (?) 10–12  $\times$  4–5  $\mu$ ; hyphis hymenii pallidis, irregularibus, 1 $\frac{1}{2}$ –4  $\mu$ ; pilei 2–4, aliqua inflata 5–6  $\mu$ .

Hab. ad truncos Brasiliae, Rick. (*Weir* 19396.)

Dem *Polyporus melleo-fulvus* Romell verwandt, der auch *Trametes* sp. ist.

***Poria crustulina* Bres. n. sp.**

Longe lateque effusa, crustulina, subiculo subtenui, albo, margine albo tomentoso, demum subsimilari; tubulis 2–3 mm. longis; poris ut plurimum angulatis, 2–3 raro 4 pro mm.; sporis hyalinis, cylindraceo-curvulis, basi saepe subuncinatis, 6–9 x 3–3½ µ; basidiis clavatis, 15–20 x 4–6 µ; hyphis ex parte tenuibus, septatis, raro nodosis et ex parte crasse tunicatis, 2–4 raro 5 µ crassis.

Hab. ad truncos *Piceae Engelmanni* et *P. sitchensis*, Washington, Montana. (*Weir* 1064, 8162, 15025, 15101.)

Diese Art ist von der Verwandtschaft von *Poria luteo-alba*, *P. levis* und *P. hibernica*, aber durch Farbe, Sporen und Struktur ganz verschieden.

***Poria dichroa* Bres. n. sp.**

Resupinata, albo-fuscescens, mollis, in plagulas ellipsoideas distributa, subiculo plus minusve crassiusculo, fulvo, margine elevato, interdum breviter reflexo, villosulo; tubulis 1–2 mm. longis; poris angulatis, mediocribus, ore demum fimbriatis, 3–4 pro mm.; sporis hyalinis, cylindraceo-curvis, 5½–6 x 1½–1¾ µ; hyphis hymenii hyalinis, 2½–3½ µ; subiculi fulvis, 3–3½, raro 4 µ, homogeneis.

Hab. ad truncos *Pini contortae*, *Abietis grandis*, *Tsugae heterophyllae* et *Pseudotsugae taxifoliae*, Idaho, Montana. (*Weir* 12074, 16081, 12926, 16082.)

Diese Art steht in der Nähe von *Poria levis* und *Poria luteo-alba* (Karst.) Sacc. aber ganz verschieden, besonders durch Subiculum immer vorhanden und colorirt.

***Poria fagicola* Bres. n. sp.**

Effusa, ex albo pallide straminea, subiculo tenui, albo, margine albo-pruinoso; tubulis vix 1 mm. longis; poris irregularibus saepe angulatis, 3–4 pro mm., dissepimentibus obtusis; sporis hyalinis, subellipticis, 4–4½ x 2–2½ µ; basidiis clavatis, 12–15 x 3–4 µ; hyphis septatis, non nodosis, tenuibus, subirregularibus, 3–9 µ crassis.

Hab. ad truncos *Fagi ferrugineae*, Washington, D. C. (*Weir* 19070.)

Ganz in der Nähe von *Poria mucida* Pers. aber durch kleinere Sporen und Hyphen viel breiter verschieden.

***Poria fulvella* Bres. n. sp.**

Late effusa, tenuis, e luteo-fulvella, subiculo nullo, margine pruinoso, albido, mox similari; tubulis  $\frac{1}{2}$ –1 mm. longis; poris variantibus, subrotundatis, angulatis vel oblongis,  $\frac{1}{2}$ –1 mm. latis, dissepimentibus obtusis; sporis hyalinis, subellipticis,  $6\frac{1}{2}$ –7 $\frac{1}{2}$  x  $3\frac{1}{2}$   $\mu$ ; basidiis clavatis, 15–18 x 5–6  $\mu$ , 2–4 sterigmatibus; sterigmatibus 3–4  $\mu$  longis; hyphis tenuibus, ramosis, 2–4 raro 5  $\mu$  crassis.

Hab. ad truncos *Pini contortae*, Idaho. (Weir 17043.)

Dem *Poria bombycina* verwandt, aber durch Farbe und kleinere Sporen verschieden. Bei *Poria bombycina* die Sporen sind 6–8 x 5  $\mu$  und die Farbe gelbbraun.

***Poria proxima* Bres. n. sp.**

Late effusa, substrato tenui, albo, margine subfimbriato; tubulis vix efformatis; poris impressis, irregularibus, rotundatis, angulatis v. oblongis, 2–4 pro mm., alutaceis; sporis hyalinis, oblongis,  $5\frac{1}{2}$ –7 x  $3\frac{1}{2}$ –4 $\frac{1}{2}$   $\mu$ ; basidiis clavatis, 24–26 x 5–6  $\mu$ ; cystidiis clavatis, granuloso-scabris, 24–50 x 5–7  $\mu$ ; hyphis contextus 2–5  $\mu$  crassis, septatis, non nodosis, crassiuscule tunicatis.

Hab. ad truncos *Hicoriae albae*, Indiana. (Weir 3479.)

Obs. Videtur *Poriae mucidae* Pers. proxima et praecipue praesentia cystidiorum diversa.

***Poria similis* Bres. n. sp.**

Late effusa, tenui, margine pruinoso, e luride alba alutacea; tubulis vix manifestis, poris impressis, dissepimentibus obtusis, 4–6 pro mm.; sporis  $4\frac{3}{4}$ –5 x  $3\frac{1}{2}$ –4 $\frac{1}{2}$   $\mu$ ; basidiis 15–18 x 4–5  $\mu$ ; cystidiis clavatis, furfuraceis, 15–25 x 6–9  $\mu$ ; hyphis contextus  $1\frac{1}{2}$ –4  $\mu$ , septatis, raro nodosis, tenuiter tunicatis.

Hab. ad truncos *Populi trichocarpae*, Coolin, Idaho. (Weir 11565.)

Obs. *Poriae corticolae* valde similis, sed sporis minoribus et praesentia cystidiorum bene distincta.

***Poria vicina* Bres. n. sp.**

Late effusa, ex albido lignicolor, subiculo tenui, a'lbo, margine e pruinato similari; tubulis 1–4 mm. longis; poris subrotundis v.

angulatis, 2-3 pro mm.; sporis hyalinis, oblongis, subellipticis, 6-8 x  $3\frac{1}{2}$ -4  $\mu$ ; basidiis clavatis, 12-15 x 4  $\mu$ ; cystidiis capitato-furfuraceis, 15 x 9  $\mu$ , capitulo deterso, 9  $\mu$  crasso; hyphis subirregularibus, septatis, non nodosis, tenuiter tunicatis,  $1\frac{3}{4}$ -3 $\frac{1}{2}$   $\mu$ .

Hab. ad truncos *Abietis grandis*, Idaho, Washington. (Weir 11541, 12077, 16085.)

Von Aussehen dem *Poria crustulina* ähnlich, aber durch Sporen und Context verschieden und mehr dem *Poria subacida* verwandt.

***Poria zonata* Bres. n. sp.**

Valde effusa, alba, demum straminea, margine zona membranacea, sterili cincta, subiculo membranaceo,  $\frac{1}{2}$  mm. crasso; tubulis 1-3 mm. longis; poris majusculis, irregularibus, 1-2 mm. latis; sporis cylindraceo-curvulis, hyalinis, biguttulatis, 5-6 x 2-2 $\frac{1}{2}$   $\mu$ ; basidiis clavatis, 18-20 x  $3\frac{1}{2}$ -4 $\frac{1}{2}$   $\mu$ ; cystidiis ventricosocuspidatis, furfuraceo obductis, 45-46 x 15-18  $\mu$ ; hyphis tenuibus, laxe septatis, 2-4  $\mu$ , juxta septa interdum uno latere incrassatis.

Hab. ad truncos *Abietis grandis*, Idaho. (Weir 15910.)

Dem *Poria radula* von Aussehen ganz gleich, aber, besonders durch Sporen, gut verschieden.

***Lentinus dentatus* Bres. n. sp.**

Pileo infundibuliformi, glabro, e centro ad marginem dense striato sulcato, castaneo-fusco v. cacinio, margine dentato, 2-3 cm. lato; lamellis decurrentibus, umbrinis; acie integra, stipite tereti, cavo, concolori, tomentoso-hirto, 3-5 cm. longo, 2-3 mm. crasso; sporis non inventis; basidiis 30 x 4-5  $\mu$ ; hyphis contextus lamellarum  $1\frac{1}{2}$ -3  $\mu$ , homogeneis, tenacibus.

Hab. Brasilia. (Weir 14364.)

Obs. *Lentino velutino* affinis, sed pileo glabro sulcato optime diversus.

TRENTO, ITALY.



## CULTURE EXPERIMENTS WITH HETEROECIOUS RUSTS IN 1922, 1923 AND 1924

W. P. FRASER

Culture experiments with heteroecious rusts were continued in 1922, 1923 and 1924. The following are some of the more interesting results. Inoculations were made with telial material by first placing it in a moist chamber until the telia were producing basidiospores. Pots containing the plants to be infected were placed in inoculation boxes and the material bearing the germinating telia was suspended over the potted plants. The plants were sprayed with water and left in the inoculation box for about forty-eight hours. The same method was followed when aecial material was used, but it was suspended at once over the plants to be tested. The grasses used were grown in the greenhouse from seed or in a few cases from plants taken in the previous season.

### PUCCINIA CLEMATIDIS (DC.) LAGERH.

In 1922 inoculations with abundant aecia in good condition from *Anemone cylindrica* and *A. globosa* were made on a number of grasses. Very heavy infection resulted with the development of uredinia and telia on *Agropyron tenerum*, *A. spicatum*, *A. dasystachyum* and *E. canadensis*. There was only a moderate infection on *Elymus virginicus* and *Hystrix patula*; weak infection on *Elymus curvatus* and no infection on *Bromus Pampellianus*, *Festuca elatior*, *Poa pratensis*, *P. compressa* and *Triticum aestivum*. Inoculations with the uredospores from the culture on *Agropyron dasystachyum* produced weak infection on *Elymus curvatus* and *E. robustus*, and negative results on *Agropyron Smithii* and *Hordeum jubatum*.

In 1923 inoculations with aecia on *Anemone globosa* and *A. cylindrica* produced heavy infection on *Agropyron spicatum*, *A. Richardsonii*; moderate infection on *Elymus canadensis* and *E. diversiglumis*; weak infection on *Elymus curvatus*, and negative results on *Agropyron repens*, *Bromus ciliatus*, *B. Pampellianus* and *Elymus innovatus*.

Aecia on *Actaea* collected at Winnipeg gave good infection on *Hystrix patula*.

*Puccinia Clematidis*, as it has been regarded by Arthur, is a species consisting of several biological races all having aecia on Ranunculaceae. Much culture work must be done before the limits of the various races will be known. Several races, however, are indicated.

A race with aecia on *Actaea* and telia on *Hystrix* and some species of *Elymus*, chiefly *E. virginicus* and *E. canadensis*.

A race with aecia on *Anemone* and telia on several species of *Agropyron* and *Elymus*.

The form of *Puccinia Clematidis* with many-celled teliospores, which has been collected on *Bromus ciliatus* and *B. latiglumis* from southern Manitoba to northern Saskatchewan, is a distinct race with aecia on *Thalictrum* (see Mycologia 12: 292-294. 1920). Probably it should be regarded as a distinct species.

Field evidence also suggests a distinct race with two-celled teliospores on *Bromus* (chiefly *B. ciliatus* and *B. Pumpellianus*). The aecia are also on *Thalictrum*.

It seems probable also that there is another race with telia on *Elymus canadensis*, *E. curvatus* and *E. Macounii*.

Field evidence also suggests a race with aecia on *Halerpestes Cymbalaria*, and telia on *Puccinellia*.

The aecia on *Ranunculus* collected in Western Canada as far as tested belong to the closely related *Uromyces Alopecuri* Symb., on *Alopecurus aristulatus*. (See Mycologia 11: 129-130. 1919.) In Eastern Canada aecia on *Ranunculus acris* are connected with *P. Clematidis* on *Alopecurus pratensis*. (See Mycologia 4: 179. 1912.)

#### PUCCINIA CORONATA CDA.

Arthur has placed the coronate forms of *Puccinia* on various grasses and the aecia on *Rhamnus*, *Elaeagnus* and *Lepargyreae* under *Puccinia coronata* Cda. Considerable cultural work has been done by investigators in Europe and America which shows the relationships of the aecia on *Rhamnus*, but as far as the author is aware no cultures have been made to establish the connections of the aecia on *Lepargyreae*<sup>1</sup> and *Elaeagnus*. They have

<sup>1</sup> Since the above was written I have learned that Bethel made cultural

usually been referred to *Aecidium Allenii* Clinton. Aecia on *Rhamnus cathartica*, *Lepargyrea canadensis*, *L. argentea* and *Elaeagnus commutata* are usually abundant in the districts around Saskatoon, and collections of aecia have been made on *Rhamnus alnifolia*, the only native *Rhamnus* in Saskatchewan. Coronate forms of *Puccinia* are common on *Avena sativa*, *A. fatua* and *Scolochloa festuacea*, the latter grass being very common in the sloughs of Saskatchewan. Collections have also been made on *Agropyron tenerum*, *Beckmannia erucaeformis*, *Bromus ciliatus*, *B. Pumpellianus*, *Deschampsia caespitosa*, *Elymus canadensis*, *Calamagrostis canadensis*, *C. inexpansa* and *C. elongata*. It seemed important to determine the relationships of these forms, especially their relationship to the form of *Puccinia coronata* Cda. on oats.

The silverberry, *Elaeagnus commutata*, is very common on the prairies of central and northern Saskatchewan and nearly every season is very heavily covered with aecia. In 1922 aecia were obtained in great abundance and in excellent condition near Saskatoon and inoculations were made on a number of grasses, but without result. In the spring of 1923 strong field evidence was secured that the aecia on *Elaeagnus* were connected with a coronate *Puccinia* on *Calamagrostis inexpansa* A. Gray. Telia collected on this host in the spring gave excellent germination and inoculations were made in the greenhouse on *Lepargyrea canadensis*, *L. argentea* and *Elaeagnus commutata*. There was no infection except on *Elaeagnus commutata* (two plants) which developed pycnidia in ten days and aecia sixteen days after inoculation. Inoculations were also made with aecia from *Elaeagnus commutata*, collected at Saskatoon on two pots of *Calamagrostis inexpansa*. Heavy infection followed with abundant development of uredinia and telia. The experiments with studies of the aecia on *Lepargyrea canadensis* several years ago. He has generously given me permission to state his unpublished results. Using aecia from *Lepargyrea canadensis* he obtained good infection on *Bromus Pumpellianus*, *B. ciliatus*, *Agropyron* spp., *Calamagrostis canadensis* and *Trisetum subspicatum*. He also obtained aecia on *Lepargyrea canadensis* using telia from all of these grasses. The uredinia and telia on the grasses were almost identical with those of *Puccinia coronata*. Though cultures were not made with aecia from *L. argentea* yet from field evidence he believes that the form on *L. argentea* is identical with that on *L. canadensis*.

aecia were repeated in 1924 with like results. During the years 1922, 1923 and 1924 the following grasses were inoculated with aecia with negative results: *Agropyron dasystachyum*, *A. tenerum*, *A. Richardsonii*, *A. Smithii*, *A. spicatum*, *Alopecurus aristulatus*, *Avena sativa*, *Beckmannia erucaeformis*, *Bromus ciliatus*, *B. latiglumis*, *B. Porteri*, *B. Pumpellianus*, *Calamagrostis canadensis*, *C. elongata*, *Deschampsia caespitosa*, *Elymus curvatus*, *E. canadensis*, *E. diversiglumis*, *E. innovatus*, *Hordeum jubatum*, *Koeleria gracilis*, *Lolium perenne*, *Scolochloa festuacea*, *Sporobolus cryptandrus*, *Stipa viridula* and *Torresia odorata*. There was no evidence of flecking or infection on any of the grasses and no trace of infection on *Avena sativa*, though inoculations on several pots were made each year.

It would seem from these experiments that the form of *Puccinia coronata* having aecia on *Elaeagnus* is highly specialized, having telia on *Calamagrostis inexpansa* and aecia on *Elaeagnus commutata*. This rust has been cultured in the greenhouse on *Calamagrostis inexpansa* for several months, so that without doubt it is a very congenial host.

The buffalo-berry, *Lepargyrea canadensis* (L.) Greene, which is common in northern Saskatchewan usually shows abundant aecia every season. Field evidence very strongly indicated its connection with a coronate *Puccinia* on *Bromus ciliatus*, and there was some evidence that it was also connected with telia on *Agropyron tenerum* and *Elymus canadensis*. Excellent material was obtained in the spring of 1924 and inoculations were made on a number of grasses with heavy infection on *B. ciliatus*, *B. Porteri* and *B. latiglumis*; moderate infection on *Phalaris arundinacea*, *Calamagrostis inexpansa* and *Beckmannia erucaeformis*, and slight infection on *Agropyron Richardsonii*, *A. spicatum* and *Bromus Pumpellianus*. There were no results from inoculations on *Avena sativa*, *Calamagrostis canadensis*, *C. elongata*, *Elymus canadensis*, *E. diversiglumis*, *Scolochloa festuacea*. Further inoculations were made with urediniospores developed from these cultures with moderate infection on *Lolium multiflorum*; weak infection on *Agropyron dasystachyum* and *Festuca viridula*, and no infection on *Deschampsia caespitosa*, *Scolochloa festuacea* and *Hystrix patula*. From these experi-

ments it would seem that the aecia on *Lepargyrea canadensis* in central and northern Saskatchewan are connected with a form of *Puccinia coronata* on *Bromus*, and that under very favorable conditions uredinia and telia may develop on *Phalaris arundinacea*, *Beckmannia erucaeformis* and several other grasses. This form has been cultured in the greenhouse for several months on *Bromus Porteri*, *B. latiglumis*, and *B. ciliatus*, so there is no doubt these are congenial hosts.

Davis (Trans. Wisc. Acad. Sci. 21: 299-301. 1924) described culture experiments which indicate that the aecia on *Lepargyrea canadensis* (L.) Greene in Wisconsin are connected with a rust on a sedge which he described as *Puccinia Caricis-shepherdiae*. There seems no doubt, however, from the cultures and field observations described here that the aecia on *Lepargyrea canadensis* in Saskatchewan are connected with a coronate rust with uredinia and telia chiefly on *Bromus*.

Aecia were collected on *Rhamnus alnifolia* near Saskatoon. Inoculations on *Calamagrostis canadensis* and *Scolochloa festuacea* produced heavy infection with abundant uredinia and telia. Rather weak infection was obtained on *Bromus Porteri* and *Avena sativa*. Very small uredinia developed on the latter host followed by a few telia. There was no infection on *Elymus curvatus*.

Aecia on *Rhamnus cathartica* were collected near Saskatoon in 1924 and inoculations made on a number of grasses. Very heavy infection resulted on *Avena sativa* and *A. fatua* with abundant development of uredinia and telia; moderate infection on *Bromus Porteri* and *Festuca viridula*, and rather weak infection on *Alopecurus aristulatus*. There was no infection on *Agropyron tenerum*, *A. spicatum*, *Bromus Pumpellianus*, *B. ciliatus*, *Calamagrostis elongata*, *Deschampsia caespitosa*, *Elymus diversiglumis*, *E. curvatus*, *E. innovatus*, *Festuca elatior*, *Hordeum jubatum*, *Koeleria cristata*, *Hystrix patula*, *Muhlenbergia racemosa*, *Poa triflora*, *Sphenopholis obtusata*, *Torresia odorata* and *Carex filifolia*.

#### AECIDIUM ALLENII CLINTON

The buffalo-berry, *Lepargyrea argentea* (Nutt.) Greene, is common along the banks of the Saskatchewan near Saskatoon, and usually is attacked by the aecial stage of a rust. There was

an exceedingly heavy infection in 1922 and 1923 which suggested the alternate host to be growing near. Most careful examination was made of the grasses in the vicinity, but no field evidence whatever could be found to give a clue to the connection of the aecia. Inoculations were made on all the grasses that were likely to bear a connected telial form but without result. There was no indication whatever of infection on any of the grasses inoculated. The aecial material was abundant and in excellent condition. The following grasses were tested, with negative results: *Agropyron dasystachyum*, *A. Richardsonii*, *A. tenerum*, *A. repens*, *A. spicatum*, *A. Smithii*, *Avena sativa*, *Alopecurus aristulatus*, *Beckmannia erucaeformis*, *Bromus ciliatus*, *B. latiglumis*, *B. Porteri*, *B. Pumpellianus*, *Calamagrostis canadensis*, *C. inexpansa*, *C. elongata*, *Deschampsia caespitosa*, *Elymus canadensis*, *E. curvatus*, *E. innovatus*, *E. diversiglumis*, *E. Macounii*, *Festuca elatior*, *F. viridula*, *Torresia odorata*, *Scolochloa festucaeae*, *Carex filifolia*.

From these cultural and field studies the writer is of the opinion that the aecia on *Lepargyrea argentea* do not belong to a form of *Puccinia coronata* Cda.

#### PUCCINIA SUBNITENS DIET.

Telia of *Puccinia subnitens* on *Distichlis spicata* were collected at Saskatoon. Inoculations on *Plantago eriopoda* Torr., and two pots of *Glaux maritima* L., were followed by pycnia and aecia. This confirms previous work. (See Mycologia 14: 228. 1922.)

#### PUCCINIA ANGUSTATA PECK

Field evidence suggested the connection of a rust regarded as *Puccinia eriophori* Thüm. on *Eriophorum angustifolium* Roth., with aecia on *Lycopus asper* Greene. Collections of telial material on *Eriophorum angustifolium* were made at Saskatoon. The teliospores germinated freely and inoculations were made on *Lycopus asper*, *Mentha* sp. and *Senecio canus*. Very heavy infection followed on *Lycopus asper* but no infection on the others. The plants of *Mentha* and *Senecio* were not in a healthy condition, so the negative evidence is of little or no value. Arthur (Mycologia 8: 131, 132. 1916) has shown that *Puccinia Eriophori* on

*Eriophorum* has aecia on *Senecio aureus* L. He points out that the morphological differences between *P. angustata* and *P. Eriophori* are not very marked. From a study of the material at hand it seemed to the writer that the rust collected on *Eriophorum angustifolium* and used in this culture was *P. angustata* rather than *P. Eriophori*.

#### PUCCINIA ANDROPOGONIS SCHW.

Aecia in excellent condition were collected on *Penstemon acuminatus* Dougl. near Saskatoon in 1924. Inoculations in three pots of *Schizachyrium scoparium* (Michx.) Nash resulted in the development of abundant uredinia and telia of *Puccinia Andropogonis* on all the plants inoculated. The check plants remained free from infection.

Arthur has shown by cultures many times that *Puccinia Andropogonis* has aecia on species of *Penstemon*. (See Mycologia 4: 17. 1912.)

#### GYMNOSPORANGIUM JUVENESCENS KERN

Telia of *Gymnosporangium juvenescens* collected at Saskatoon on *Sabina horizontalis* (Moench) Rydb. were germinated in a moist chamber. Inoculations on *Amelanchier alnifolia* Nutt., and *Crataegus chrysocarpa* Ashe, resulted in very heavy infection with abundant development of pycnia and aecia on *Amelanchier alnifolia*, but no infection on *Crataegus*. Arthur (Mycologia 4: 61, 62. 1912) previously established this connection by cultures.

#### GYMNOSPORANGIUM CORNICULANS KERN

Inoculations with germinating telia from *Sabina horizontalis* collected at Saskatoon infected *Amelanchier alnifolia* heavily, but failed to infect *Crataegus chrysocarpa*. This connection was previously established by Arthur (Mycologia 2: 235-236. 1910.)

#### MELAMPSOROPSIS PYROLAE (DC.) ARTH.

Germinating telia were collected on *Pyrola asarifolia* at Duck Lake, Sask., and inoculations were made on the cones of *Picea canadensis* growing on the grounds of the University of Saskatchewan on June 5. The branches bearing the cones were then enclosed in celluloid cylinders and kept moist and shaded for

two days. Pycnia appeared on June 30 on one cone that had been inoculated, followed by aecia, which were shedding spores on August 23. There was no infection on the cones on the surrounding trees. The cones were rather young when inoculated and this may account for the scant infection. Previous experiments indicated that better infection was secured when the cones were well developed at the time of inoculation.

(The work of the cultures was largely performed by members of the staff of the Dominion Laboratory. The writer wishes to acknowledge this aid, especially that of Messrs. P. M. Simmonds, R. R. Hurst and R. C. Russell. Acknowledgment is also made of the determination of several grasses by Dr. M. O. Malte of Ottawa.)

#### SUMMARY

*Puccinia Clematidis* (DC.) Lagerh. Inoculations with aeciospores from *Anemone cylindrica* A. Gray and *A. globosa* Nutt. infected heavily *Agropyron tenerum* Vasey, *A. spicatum* (Pursh) Scribn. & Smith, *A. dasystachyum* (Hook.) Scribn., *A. Richardsonii* (Trin.) Schrad., and *Elymus canadensis* L., and rather weak infection on a number of other grasses.

Inoculations with aeciospores from *Actaea* sp. readily infected *Hystrix patula* L.

*Puccinia coronata* Cda. Teliospores from *Calamagrostis inexpansa* A. Gray infected heavily *Elaeagnus commutata* Bernh. Aeciospores from *Elaeagnus commutata* infected heavily *Calamagrostis inexpansa*.

Aeciospores from *Lepargyrea canadensis* (L.) Greene infected heavily *Bromus ciliatus* L., *Bromus Porteri* (Coult.) Nash, and *Bromus latiglumis* (Shear) Hitchc., and weakly infected a number of other grasses.

Aeciospores from *Rhamnus alnifolia* L'Her infected heavily *Calamagrostis canadensis* L., and *Scolochloa festuacea* (Willd.) Link, and rather weak, a number of other grasses.

Aeciospores from *Rhamnus cathartica* L. infected heavily *Avena sativa* L., *A. fatua* L., and rather weak, a number of other grasses.

*Puccinia subnitens* Diet. Teliospores from *Distichlis spicata* Coult. & Nels. infected heavily *Plantago eriopoda* Torr. and *Glaux maritima* L.



*Puccinia angustata* Peck. Teliospores from *Eriophorum angustifolium* Roth. readily infected *Lycopus asper* Greene.

*Puccinia Andropogonis* Schw. Aeciospores from *Penstemon acuminatus* Dougl. infected heavily *Schizachyrium scoparium* (Michx.) Nash.

*Gymnosporangium juvenescens* Kern. Teliospores from *Sabina horizontalis* (Moench) Rydb. infected *Amelanchier alnifolia* Nutt.

*Melampsoropsis Pyrolae* (DC.) Arth. Inoculations with teliospores from *Pyrola asarifolia* Michx. infected the cones of *Picea canadensis* (Mill.) BSP.

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## NOTES AND BRIEF ARTICLES

Dr. C. H. Kauffman, of the University of Michigan, is spending several days at The New York Botanical Garden continuing his studies on certain of the higher fungi preparatory to a monograph of this group.

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Mr. Rafael Toro, from the Porto Rican Experiment Station, recently spent a few days at The New York Botanical Garden in connection with the study of the Pyrenomycetes of Porto Rico. Mr. Toro is spending a year at Cornell University in mycological work under the direction of Professors Whetzel and Fitzpatrick.

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Professor James McMurphy of Stanford University, California, spent several days at the Garden looking over the fungous collections and methods of preserving fungi in the herbarium. Professor McMurphy is in charge of the phytopathological and mycological work in the University.

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Mycologists will be glad to welcome the appearance of Dr. Roland Thaxter's third part of his "Contribution Toward a Monograph of the Laboulbeniaceae." This part deals with the group Dimorphomyceteae including the six genera *Trenomycetes*, *Polyandromycetes*, *Nycteromycetes*, *Dimorphomycetes*, *Dimeromycetes*, and *Eudimeromycetes* and consists of 113 pages and 12 plates. The plates are done in the same style and with the same degree of excellence as those of the preceding parts. The work is published as the "Memoirs of the American Academy of Arts and Sciences," Number V, and is a valuable contribution to science.

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### BROWN CANKER OF ROSES

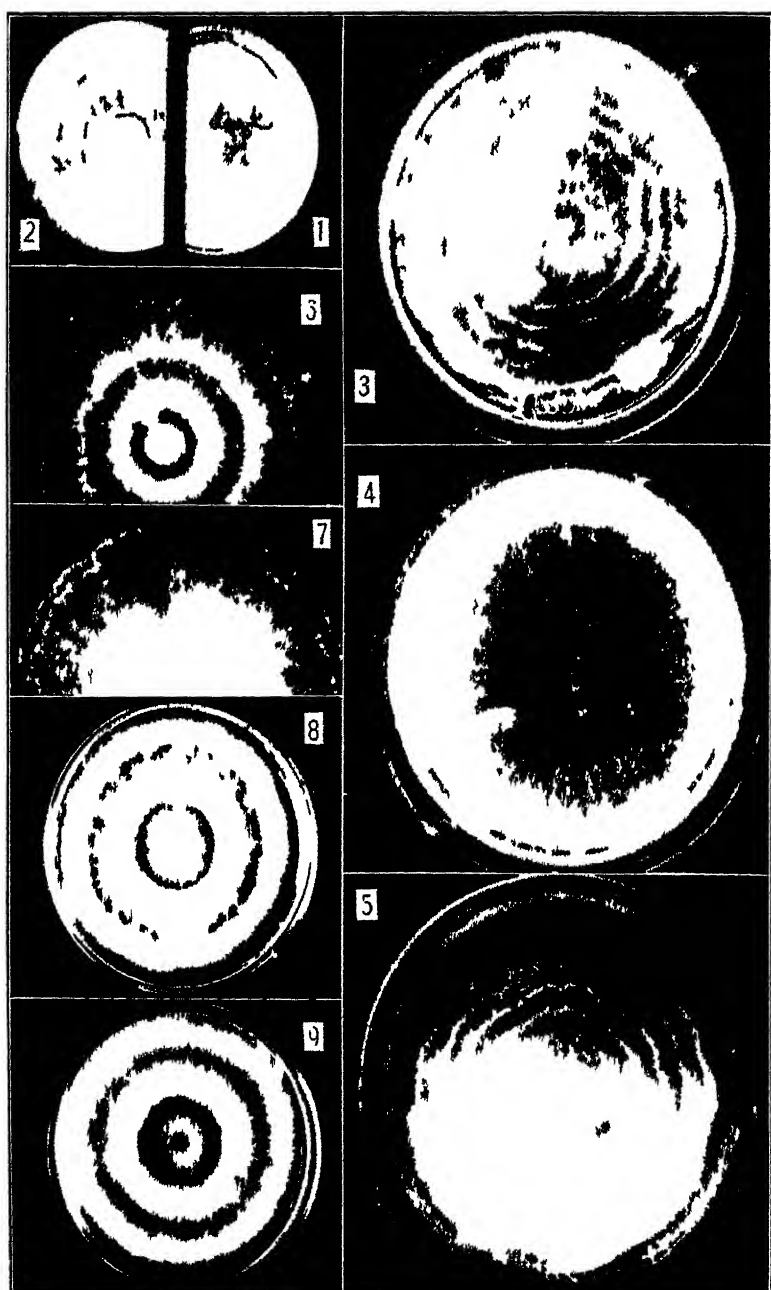
A serious attack of the disease known as brown canker of roses was observed on August 23 among the outdoor roses at the New

York Botanical Garden, Bronx Park, New York. At that time the symptoms were particularly conspicuous on the blossoms. On the discolored petals exuded spore masses of the imperfect stage of the pathogene, *Diaporthe umbrina* Jenkins, were plainly visible with the aid of a hand lens. This trouble had been prevalent throughout the season and the gardeners had attributed it to weather conditions. The attractiveness of the rose garden was considerably lessened by the numbers of affected blossoms.

The disease has been reported as producing stem cankers at the National Rose Test Garden, Arlington Experiment Farm, Rosslyn, Virginia. It has also been observed on blossoms and other parts of the plant at a number of other places and is apparently one of the most important fungus troubles of the rose, the so-called continuous blooming varieties being particularly susceptible. The disease is known to have been present in America for a considerable period but has not generally been recognized.

ANNA E. JENKINS





ZONATION IN CULTURES OF FUNGI

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## ZONATION IN CULTURES OF *FUSARIUM* *DISCOLOR* *SULPHUREUM*

G. R. BISBY

(WITH PLATE 8)

The effect of light upon plants has received considerable attention of late. Exact quantitative and qualitative measurements have been made of the influence of light in causing phototropic turning of the coleoptiles of oats (see Nienburg, 1919, Guttenberg, 1919, Koningsberger, 1923). The coleoptile appears to respond to a definite intensity of light: Guttenberg finds, for example, that twice as much light is required for the turning, if the coleoptile be shaded along half its longitudinal area, as is required with unshaded coleoptiles. It has long been known that the sporangiophores of *Phycomyces* and of *Pilobolus*, and the fruit bodies of various other fungi, turn toward the light in a manner comparable to the turning of oat coleoptiles. Tollenaar and Blaauw (1921) discuss the changing adaptations of sporangiophores of *Phycomyces nitens* to light, their sensitiveness depending upon the amount of light to which they had been exposed before a new light intensity was used. Oltmanns (1907) had also noted that the more accustomed the sporangiophores become to light, the higher is the light intensity required for the optimum phototropic response. Blaauw (1919) considers that in the cases of phototropic turning of coleoptiles or of sporangiophores in unilateral illumination, the phototropism is a manifestation of a localized growth response to the light; that the phenomenon of phototropism is a secondary phenomenon, the growth reaction being the primary one.

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Light is important to many fungi. Miss Westerdijk (1923) of the "Centraalbureau voor Schimmelcultures" records that fungi in general require light, which may influence fruiting. Leonian (1924) found that, of twenty Sphaeropsidales which he grew in culture, no pycnidia were produced in darkness by two species, twelve others showed reduced reproduction in darkness, and only six were unaffected by darkness. The Agaricaceae may also require light: MacDougal (1903) found that *Coprinus stercorarius* produced only rudimentary fruit bodies in darkness, but produced normal pilei when light was allowed to act. Brefeld had previously noted similar cases. Buller (1909) found that the pilei of *Lentinus lepideus* and of *Polyporus squamosus* were formed as a response to the morphogenic stimulus of light, these fungi being quite sterile in total darkness. Buller also notes that in the rhythmic diurnal development of certain small *Coprini*, light acts as a causal stimulus; but he points out that certain fungi, such as *Psalliota campestris*, develop normally in darkness. *Pilobolus*, according to Buller (1921), possesses a pigmented "eye spot" which serves to direct the sporangium toward a source of light.

The formation of zones, *i.e.*, concentric rings, in cultures of fungi on petri dishes, etc., is a very commonly observed phenomenon. It has often been observed that one such ring is formed each day. Hedgcock (1906) noted these zones in cultures of *Cephalothecium*, *Penicillium*, *Mucor* and *Hormodendron* exposed to daylight or to blue light during the day. No such zonation was found in cultures grown continuously in the dark, or in red or orange light during the day. Stevens and Hall (1909) record that light causes the formation of zones in some fungi, although in others the zones appear to have no reference to illumination. Molz (1906) had found that diurnal changes in light conditions cause the formation of concentric zones in cultures of *Sclerotinia fructigena*, the conidial cushions being scattered or absent in darkness. Hutchinson (1906-7) also records the formation of concentric zones in *Penicillium* and *Oidium lactis* as a response to light. Milburn (1904) had found that concentric zones were produced in cultures of *Hypocrea rufa* in certain media, but were absent in other media, the medium, not light, being the agent

involved in the zone formation. Gallemaerts (1910) found that the zones in *Cephalothecium roseum* and other fungi were caused by the alternation of light and darkness, light appearing to hinder the formation of spores. He found that an all-day exposure to red, orange, or blue light, alternating with darkness caused zone formation, but that no zones appeared when the fungi were exposed to continuous light or continuous darkness. He thus differs from Hedgcock as to the effect of red and orange light. Allen and Jolivette (1914) state that *Pilobolus* is not strongly phototropic toward yellow light, and still less so toward red light. Miss Parr (1918) measured carefully the effect of different portions of the spectrum upon the phototropic response of *Pilobolus*, and found that presentation time decreases gradually from the red to the violet end of the spectrum, the time varying in inverse ratio to the square root of the wave frequency of the light.

#### EXPERIMENTAL RESULTS

The writer had had *Fusarium discolor sulphureum* in culture for several years. This fungus is a common cause of tuber rot of potatoes in Minnesota (Bisby, 1919) and in Manitoba. It grows well and produces macroconidia abundantly (so long as the culture is a "high culture") in either light or darkness. Morris and Nutting (1923) record that light in general has no appreciable effect upon growth of *Fusaria* except in heightened color in cultures grown in diffuse light.

In working with *Fusarium discolor sulphureum*, at the University of Minnesota in 1918 and 1919, it was found that a moderately short exposure to light suffices to induce the formation of rings of spores. When cultures growing in a dark incubator were removed to the daylight only long enough to mark with a wax pencil the limits of growth, then replaced in the incubator, it was observed that by the following day (or even after about 7 hours) a ring of macroconidia could easily be seen. The ring was formed directly under the pencil mark. No effect was noted on the portions of the culture elsewhere than at the tips of the hyphae. If two exposures were made during one day, two rings were produced. If the cultures were kept in darkness, no rings resulted, yet many conidia were produced irregularly over the



culture. Figs. 1 and 2 show photographs of these cultures taken at Minnesota.

The writer recently made attempts to determine more definitely the amount of light required to produce these rings, since no reference to this point was found in the literature. In an endeavor to determine the amount of daylight required, attempts were first made with camera shutters, but the amount of light reaching the cultures was greatly reduced by the small size of the opening. Finally, the cultures on beef-extract agar with two percent glucose in petri dishes were placed in tight boxes with lids. Then by a little practice with an empty box in which the operation was timed with a watch and compared with the time of opening of the shutter of a camera, it was found that the lid could be opened and closed by hand with an approximation to  $1\frac{1}{2}$ ,  $\frac{1}{2}$ , or  $\frac{1}{4}$  second exposure to full daylight of the culture within. The petri dishes were exposed to the diffuse light from a west window in the afternoons. The amount of light of course varied from day to day and, furthermore, passed through a window pane and through the glass of the petri dish. Several trials demonstrated that under the conditions, an exposure of one-fourth to one-half second on a bright day, or one-half to one second on a dull day, resulted in the production of a ring sufficiently well marked to be easily noted by the naked eye (Fig. 3). A longer exposure led to the development of a more conspicuous ring.

Cultures kept in continuous darkness (Fig. 4) or continuous light of uniform intensity, *i.e.*, in a box lighted only by an ordinary electric light bulb of about 25 candle power, showed no rings, although many macroconidia were scattered irregularly over the cultures.

Cultures exposed to the diurnal alternation of daylight and darkness show daily bands of conidia (Fig. 5).

Temperature plays an important part in the phenomenon of zonation. At temperatures below about 18° C., few macroconidia are produced, and, therefore, no zonation can occur. Fig. 7 illustrates a culture exposed to alternate light and darkness at temperatures of 16–18° C. with no zones; the two zones shown at the periphery in the illustration were formed through the influence of light only after the temperature of the culture was raised to about 21° C.

At temperatures of 30° C. or above, a dense uniform growth of conidia (pseudopionnotes) is produced even in darkness (see Bisby, 1919, p. 23) and exposure to light does not result in the formation of rings.

If a culture wrapped carefully to exclude all light is exposed to alternate high and low temperatures, such as a day in an ice box at about 10° C. followed by a day in an incubator at 25° C., followed by a return to the ice box, etc., zonation is obtained as illustrated in Fig. 6. This, however, is quite a different type of zonation from that resulting from exposure to light, the zones being made up of bands of loose hyphae with few conidia produced at the low temperature, alternating with bands of less fluffy hyphae bearing many irregularly scattered masses of macroconidia formed at high temperatures. Figs. 8 and 9 also illustrate the zonation produced in another *Fusarium* by exposure to alternating high and low temperatures.

In order to obtain more definite figures as to the amount of light required to produce a ring of conidia, use was made of an electric lamp, with a carbon filament standardized to give 25 candlepower. A number of cultures were kept either at room temperature, or were placed in an incubator at about 25° C. The cultures were fixed within boxes in pairs, and each box was wrapped in paper to keep out all light. The boxes were taken into a dark room, unwrapped, and placed at a distance of one meter from the source of light. The light from the 25 candlepower lamp was then turned on. It was found that approximately 6 minutes were required to produce a definite ring.

Since the standardized carbon lamp gave off a somewhat yellowish light, a tungsten-filament lamp, which gave a much whiter light, was tested and found also to be approximately 25 candlepower. When this tungsten lamp was used, it was found that an exposure of 2 to 2½ minutes, at one meter distance, sufficed to produce a ring as sharp as that produced by the light of the carbon lamp for six minutes. An exposure of 2½ minutes represented some 3375 meter candle seconds, a figure that may bear some approximation to from one-half to one second of daylight. Miss Jolivette (1914) found that a 16 candlepower tungsten lamp was more effective than a 32 candlepower carbon lamp in causing a reaction in *Pilobolus*.

In order to be sure that the effect was not produced by some factor connected with the handling of the cultures, *e.g.*, a slight change in temperature in removing the boxes from the incubator to the dark room for a few minutes, checks were used in which the boxes were handled in the same way, but with the light off. No zones were produced in petri dishes so treated. Other cultures were kept in continuous darkness: these showed no zonation.

A few tests have been made with other fungi, such as *Cephalothecium roseum*, *Penicillium* spp., *Verticillium alboatrum*, etc. While a similar type of zonation occurred with these fungi as a result of exposure to light, the zones were scarcely as sharp as with *Fusarium discolor sulphureum*. This *Fusarium* also appears to be more sensitive to light than the other fungi used.

It appeared to make no marked difference whether the light reached the culture from above or below, although of course there would be some absorption of light passing through the medium in cases in which the bottom of the petri dish was exposed.

#### GENERAL DISCUSSION

The production of a zone of conidia as a result of exposure to light is a response quite different from that of a phototropic turning of an *Avena* coleoptile or the sporangiophore of *Phycomyces* or of *Philobolus*. The zone comes about as a result of the subsequent formation of conidiophores and conidia at the point where the tips of the spreading hyphae receive the stimulus of light. In darkness, however, conidia are produced, but are scattered over the culture; in other words, *light results in a localization of the production of conidia in the Fusarium*. Although Hedgcock (1906) and Gallemaerts (1910) remark that light inhibits the formation of spores in the fungi with which they worked, Rahn (1912) considers that the greater production of spores by day, and of mycelium by night, accounts for the daily zones of mold colonies. My observations with *F. discolor sulphureum* indicate that fully as many conidia are produced in cultures receiving the short light stimulus as in those remaining in the darkness. It is, of course, true that the conidia are produced in the darkness during a few hours following the short

light exposure. We may perhaps consider that the light gives a brief check to the vegetative growth of the tips of the hyphae, and that the formation of conidiophores follows upon this check.

*Fusarium discolor sulphureum* develops upon potatoes in dark storage cellars, or in the soil, especially when a partially rotted tuber is planted. The production of conidia at the point where a ray of light strikes the young mycelium may serve as an aid in the dissemination of spores.

Considerably more illumination is required to produce a noticeable zone of conidia in this *Fusarium* than is required to produce a phototropic movement in a coleoptile of oats or in a sporangio-phore of *Phycomyces*. The accurate measuring of the effect of different parts of the spectrum, and of precisely the intensity of light required to produce a definite zonation, would require facilities which I have not at the moment available. The production of zones is a response to light that is easily demonstrated, and a permanent record of the result can be kept by preserving the cultures.

I am glad to express my thanks to Dr. A. H. R. Buller for critically reading the manuscript.

#### SUMMARY

1. Zonation in cultures of *Fusaria* was found to occur from the influence of light or temperature.

2. An exposure of *Fusarium discolor sulphureum* to bright daylight for one-fourth to one-half second is sufficient to produce a ring of conidia which can be detected by the naked eye.

3. A six-minute exposure to the light from a 25 candlepower carbon lamp at one meter distance was required to produce a noticeable ring, but an exposure of 2 to 2½ minutes to a tungsten-filament lamp of about the same candlepower sufficed to induce the zone-formation.

4. The light acts upon the outermost tips of the hyphae, and the phenomenon is, at least in part, another case of the effect of light upon growth.

5. Zonation may also be induced by alternating temperature in constant darkness.

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## EXPLANATION OF PLATE 8

Figs. 3, 4, 5, 6 and 7 are from prints made directly by contact with the petri dishes containing the culture. Figs. 1, 2, 8 and 9 are from photographs made at the University of Minnesota.

Fig. 1. *Fusarium discolor sulphureum*, grown in the dark, but exposed to the light and marked before the fungus had covered the plate, with the production of a ring of conidia at the point where the tips of the hyphae were exposed. Above, a little of the mark not erased, covering the ring perfectly.

Fig. 2. A culture kept in the dark in an incubator, except when exposed a moment each day to mark the limits of growth. Some of the marks have been erased. In one case a double ring is formed as a result of two exposures, about five hours apart, in one day.

Fig. 3. Inoculated May 13, 1924. Cultures exposed to daylight by opening the box containing them, before a west window at 2 p. m. each day, as noted below. The cultures were not exposed to sunlight. The fractions of seconds are approximate.

May 15, 5 sec. bright day. Ring produced.

May 16,  $\frac{1}{4}$  sec. bright day. Faint trace of a ring.

May 17, 5 sec. bright day. Well marked ring.

May 18, 1 sec. bright day. Well marked ring.

May 19, 2 sec. bright day. Well marked ring.

May 20,  $\frac{1}{4}$  sec. bright day. Slight ring.

May 21,  $\frac{1}{4}$  sec. dull day. No ring.

May 21, removed to full daylight at 5 p. m. Ring produced.

Fig. 4. Inoculated Mar. 31, 1924, kept in the dark continuously until the culture was grown over. No zonation produced. The radii are caused by shrinkage of the medium. Print made June 5.

Fig. 5. Inoculated May 13, 1924. Exposed to alternate day and night in the laboratory. Broad rings mark each day's growth.

Fig. 6. Inoculated July 3, 1924. Kept constantly in the dark. Alternated between an ice box at about 10° C., in which lighter hyphal areas were produced, and an incubator at 25° C., in which darker conidia-bearing areas were formed. The culture was alternated each 24 hours. (Since the print was made directly, the colors are reversed.)

Fig. 7. See explanation in text.

Fig. 8. *Fusarium ?culmorum*. Inoculated Mar. 2, 1919. Kept at about 15° C., for four days; on Mar. 6 the culture was placed out of doors, with the temperature close to freezing, and a bright red zone was produced by mycelium close to or sunken in the medium. Then placed in an incubator at 27°; then in an ice box at 10°, and finally back in the incubator. This fungus produced more mycelium at higher temperatures than at low temperatures, whereas *F. discolor sulphureum* produces spores abundantly at higher temperatures, and mycelium more conspicuously at lower temperatures.

Fig. 9. Reverse (lower) surface of the culture shown from above in Fig. 8.

# BOTRYOSPHAERIA AND PHYSALOSPORA IN THE EASTERN UNITED STATES

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(WITH PLATE 9)

## INTRODUCTION

So similar are *Botryosphaeria Ribis* and *Physalospora malorum*, both in the morphology of their perfect stages and in their growth on certain culture media, that they might easily have been confused even if they occurred on but few hosts. Continued collecting and study make it apparent that they are found on a great variety of host species scattered over at least the eastern part of the United States. Moreover, both fungi may occur not only on the same host species but on the same individual or part. Stromata of the two species have indeed been found several times within the space of a square centimeter of host bark.

In an earlier paper (5) the writers have compared the species on apple and currant. The present paper is essentially a progress report summarizing the results of collecting and culture work to date. Although our collection of course contains a large number of specimens which show only pycnosporos, attention will be confined in this paper to ascospore material in which the ascospores have been measured, the type of ascospore germination observed, pycnosporos produced in pure culture from single ascospores, and the pycnosporos which were produced in culture also measured. This includes seventeen hosts in the case of *Botryosphaeria Ribis* and twenty-two in the case of *Physalospora malorum*.

*Botryosphaeria Ribis* has been collected on the following hosts: *Amygdalus* sp. at Madison, Fla.; *Baccharis* sp., 2 specimens, both at Flamingo, Fla.; *Eucalyptus* sp. at Kissimmee, Fla.; *Gossypium* sp. at Sparta, Ga.; *Juglans* sp. at Seton, Del.; *Laguncularia* sp. at Flamingo, Fla.; *Liquidambar* sp., 2 specimens, one at Kissimmee, Fla., and one at Macon, Ga.; *Liriodendron* sp. at

Andersonville, Ga.; *Melia* sp., 3 specimens, one at Lake City, Fla., one at Monticello, Fla., and one at Fort Mott, S. C.; *Poinciana* sp. at Homestead, Fla.; *Pyrus Malus* at Falls Church, Va.; *Quercus* sp. at Lake City, Fla.; *Ribes* sp. at N. Rochester, Mass.; *Ricinus* sp., two specimens, both at St. Lucie, Fla.; *Rosa* sp. at Bell, Md.; *Sambucus* sp. at Titusville, Fla.; and *Vitis* sp. at Sebastian, Fla.

*Physalospora malorum* has been collected on the following hosts: *Acer* sp., five specimens, one at Orlando, Fla., one at Southern Pines, N. C., and the other three at St. Stephen, Charleston, and Aiken, S. C.; *Alnus* sp., two specimens, one at Society Hill, S. C., and one at Aiken, S. C.; *Amygdalus* sp. at Apex, N. C.; *Cercis* sp. at Madison, Fla.; *Crataegus* sp. at Aiken, S. C.; *Diospyros* sp. at Rochelle, Ga.; *Ilicoria* sp., four specimens, one each at Aiken, S. C., Monks Corners, S. C., St. Lucie, Fla., and High Springs, Fla.; *Liquidambar* sp., three specimens, one at Aiken, S. C., one at Madison, Fla., and one at Thomasville, Ga.; *Liriodendron* sp. at Aiken, S. C.; *Lucuma* sp. at Society Hill, S. C.; *Magnolia* sp. at Aiken, S. C.; *Melia* sp., three specimens, one at Madison, Fla., one at Montecello, Fla., and one at Milledgeville, Ga.; *Platanus* sp. at St. Stephen, S. C.; *Prunus* sp. at Madison, Fla.; *Pyrus Malus* at Falls Church, Va.; *Quercus* sp., six specimens, one at each of the following localities: Southern Pines, N. C., Ft. Mott, S. C., Aiken, S. C., St. Cloud, Fla., Lake Alfred, Fla., and Macon, Ga.; *Ribes* sp. at N. Rochester, Mass.; *Rubus* sp. at Society Hill, S. C.; *Salix* sp., three specimens, one at Vero, Fla., one at Pampano, Fla., and one at St. Cloud, Fla.; *Sassafras* sp., two specimens, one at Ft. Mott, S. C., and one at Andersonville, Ga.; *Citrus* sp. in Baldwin Co., Alabama; *Viburnum* sp. at Aiken, S. C.; and *Vitis* sp., two specimens, one at Aiken, S. C., and one at St. Cloud, Fla.

In the paper just mentioned (5) the writers pointed out that the chief differences between *Botryosphaeria Ribis* and *Physalospora malorum* were the differences in the life histories, the first having *Dothiorella* as its pycnidial stage and the second *Sphaeropsis* as its pycnidial stage, and the difference in the ascospore sizes. Differences were also noted in the method of germination of the ascospores and culture characters on certain culture media.



In the present paper, evidence is presented to show that these characteristic differences are constant on the various hosts from which fresh ascospore material has recently been collected. For the present, consideration will not be given to the older ascospore material which will not now germinate.

The name *Botryosphaeria Ribis* is here used for species congeneric with *B. Ribis chromogena* of G. & D. (2), as represented by specimens in Fungi Columbiani 3409. In using the name *Physalospora malorum* or *Sphaeropsis malorum* it is intended to designate the fungus causing the common black rot of apples in the eastern United States, usually and apparently correctly cited by American authors as *Sphaeropsis malorum* Peck and as represented by numerous specimens deposited by the writers in the pathological collections of the Bureau of Plant Industry and distributed in part by that herbarium. It is not intended at this time to enter into the discussion as to the specific identity or relationship of this species to *Sphaeropsis malorum* Berkeley, as found in England, or to similar species found in Europe and the northwestern United States, which have at various times been referred to as *Sphaeropsis malorum*. The writers are now inclined to believe that the safest citation for the pycnidial stage of the organism in question is *Sphaeropsis malorum* (Peck), and for the ascogenous stage, *Physalospora malorum* (Peck), instead of *Physalospora malorum* (Berk.), as previously used by them.

#### SPORE MEASUREMENTS

The most obvious and one of the most constant morphological differences between the perfect stages of *Physalospora malorum* and *Botryosphaeria Ribis* is the difference in the size of their ascospores. The lengths and widths of the ascospores of the specimens discussed in this and the earlier paper are summarized in tables 1 and 2. In general shape the ascospores of the two fungi are very similar indeed. It is, then, not surprising that these species have been confused, especially since the larger spores of *Botryosphaeria Ribis* equal in size the smaller ones of *Physalospora malorum* (Tables 1 and 2). The great majority of the ascospores of *Physalospora malorum* are, however, both longer and wider than those of *Botryosphaeria Ribis* and in good material

TABLE I  
ASCOSPORES ARRANGED BY CLASS ACCORDING TO LENGTH

	Total number of spores	Length (microns)																											
		13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40
<i>Botryosphaeria Ribis</i> on <i>Pyrus Malus</i> .....	207	1	5	13	8	22	22	14	25	19	21	33	16	3	2	2	1												
"    " <i>Ribes</i> sp. ....	226	5	7	9	25	35	27	21	24	19	22	16	6	3	3	4													
"    "    15 other hosts listed																													
in text. ....	369	1	3	6	8	30	39	39	55	25	74	43	21	19	6														
<i>Physalospora malorum</i> on <i>Pyrus Malus</i> .....	223							1	1				5	8	4	11	10	16	11	31	20	28	24	30	11	6	3	2	1
"    " <i>Ribes</i> sp. ....	146								1		4	8	9	15	9	30	15	12	21	4	6	6	3	2			1		
"    "    20 other hosts listed																													
in text. ....	844								2	5	10	23	38	55	121	117	82	117	66	89	44	28	24	12	7	4			

TABLE II  
ASCOSPORES ARRANGED BY CLASS ACCORDING TO WIDTH

	Total number of spores	Width (microns)														
		4	5	6	7	8	9	10	11	12	13	14	15	16		
<i>Botryosphaeria Ribis</i> on <i>Pyrus Malus</i> .....	207	1	11	54	94	37	10									
" " " <i>Ribes</i> sp. ....	226		8	44	91	70	11	2								
" " " 15 other hosts listed in text. ....	369		1	41	96	131	66	21	10	3						
<i>Physalospora malorum</i> on <i>Pyrus Malus</i> .....	223				25	31	46	68	26	23	3	1				
" " " <i>Ribes</i> sp. ....	146			1		2	14	23	41	33	22	9	1			
" " " 20 other hosts listed in text. ....	844				7	30	104	222	222	162	66	26	3	2		

the species may readily be distinguished by the size of their ascospores.

Not less striking than the difference in the size of the spores of the two species is the similarity in the size of the spores of each species from different hosts. While the number of spores measured from each host (except currant and apple) is not large, there is nothing to indicate that anything more than an appearance of greater accuracy would have been gained from measuring larger numbers. The agreement in the size of the ascospores from such unrelated hosts is little short of surprising, especially when it is remembered that the specimens here dealt with were collected all the way from Massachusetts and New York to southern Florida.

All the pycnospores measured were grown in pure culture from single ascospores, since with our present very limited knowledge of the species of these genera there seems to be no other method of being sure of the relation between the ascospores and the pycnospores. Merely finding them close together on a single host apparently gives no assurance that they belong even to the same genus. Pycnospores of *B. Ribis* from all seventeen hosts agree closely in size and shape, measuring  $10-29 \times 4-9 \mu$ , mostly  $18-20 \times 5-6 \mu$ . Pycnospores of *P. malorum* measure  $17-31 \times 7-15 \mu$ , mostly  $22-25 \times 9-12 \mu$ . As might be expected, agreement between pycnospores from different hosts is not as close or constant as is that of the ascospores. As yet the writers have no satisfactory information as to the extent to which the size of the pycnospores can be modified by the environment. The interesting observation of Paddock (4, p. 194 and 195) that the average size of spores of *Sphaeropsis malorum* varies according to the host on which they are grown should, however, be remembered in this connection.

#### ASCOSPORE GERMINATION

The apparently trivial character of ascospore germination has proven of great service in distinguishing the two species in culture. As noted in our earlier paper (5, p. 595, plate 2, figs. O, P, Q and R), under the conditions of our work in the laboratory at Washington, ascospores of *Botryosphaeria Ribis* characteristically

develop two germ tubes which branch before they have reached a length equal to ten times that of the spore, whereas ascospores of *Physalospora malorum* characteristically produce but one germ tube, which grows to a length often equal to fifty times the length of the spore before it branches. Even if an ascospore of *Botryosphaeria Ribis* develops but one germ tube it usually branches while still short. Not only has this difference remained constant throughout the course of our work on these species from all the hosts listed in this and earlier papers, but ascospores of other species of *Physalospora* with which we have thus far dealt have shown the same type of germination as *Physalospora malorum*.

While these differences have proven remarkably constant for the germination of these spores in agar plates at temperatures of 12 to 15° C., it is of course not to be expected that they would be equally constant in all media or at other temperatures. High temperatures would of course result in much more rapid germination and earlier branching. The difference noted has been very useful, however, in assisting in distinguishing these species, especially during the early part of our work.

#### CULTURAL CHARACTERS

In making the life history studies summarized in this paper and in their earlier work the writers have made over five thousand cultures on various media. As already noted (5, p. 597) cultures of these two species are much alike on some media, especially while young. They may be readily distinguished, however, on beef agar or on corn meal in flasks. Thus far the writers have failed to note any differences between these fungi as found on different hosts which would suggest that there might be actually different strains on the different hosts. The currant cane blight fungus, *Botryosphaeria Ribis chromogena*, which is chromogenic on starchy media, is the only strain yet distinguished by cultural characters, and this of course is not confined to currant.

#### STROMATIC CHARACTERS

Both perithecia and pycnidia of *Botryosphaeria Ribis* usually occur in a stroma. That the size of the stromata varies with the

host and the thickness of the bark was pointed out by Stevens and Jenkins (7) and the present writers (5). Perithecia of *Physalospora malorum* are usually scattered, though occasionally several are joined together. As in the case of *Botryosphaeria Ribis*, however, the size of the sporocarp of *Physalospora malorum* (6) is modified by the character of the host bark. On currant and hosts with similar bark several perithecia or pycnidia are grouped together in a single sporocarp surrounded by a mass of stromatic tissue, whereas on hosts with thinner bark or more uniform texture such as apple or willow, perithecia usually occur singly, and pycnidia either singly or in very small stromata.

With such modifications in both species on different hosts it is not surprising that the superficial appearance of the sporocarps of the two fungi is often so similar as to make them readily confused. When, however, mature perithecia of the two species are compared on bark of about the same thickness on the same host species, certain characteristic differences are apparent. The photographs in plate 9 give some idea of the appearance of the two fungi on various hosts when examined with a hand lens after the tops of the perithecia have been cut off.

The contents of mature perithecia in both species is almost snow white, a characteristic which makes it possible to identify the group with a fair degree of certainty in the field. As will be noted from plate 9, perithecia of *Botryosphaeria Ribis* are constantly smaller (averaging 165 by 130  $\mu$ ) than those of *Physalospora malorum* (which average 245 by 210  $\mu$ ) and are generally grouped in stromata. The perithecia of *Physalospora malorum* on the other hand are larger and even when they are very close together, are usually without any definite stroma. The general structure of the mature or nearly mature sporocarps suggests that interesting and significant differences would be revealed by a careful study of their development. Since, however, the two fungi occur so generally on the same host, a significant study of the development of their ascogenous stages can be made only after our technique has developed to the point where we are able to produce perithecia in quantity in pure culture.

## HOST RELATIONS

The hosts on which *Botryosphaeria Ribis* and *Physalospora malorum* have already been found are sufficient in number and so unrelated as to make it seem probable that either of these species or both of them may be found on almost any deciduous host in the eastern United States. It is perhaps somewhat at variance with general practice in mycology to consider as a single species fungi found on unrelated hosts. The writers feel, however, that the practice of describing, or naming, as "different" fungi having practically identical morphological characters merely because they happen to be found on unrelated hosts is most unfortunate, particularly in the case of saprophytic or nearly saprophytic species.

In the present case there can be no justification for such action. It is indeed made impossible by the host relations of the currant cane blight fungus, *Botryosphaeria Ribis chromogena*. *B. Ribis chromogena* is readily distinguished by its striking cultural characters and by its parasitism on currant canes. Stevens and Jenkins (7) have proven by culture studies and cross inoculations that this fungus occurs on both rose and horsechestnut as well as on currant. To their work must now be added the interesting and valuable discovery of Miss Fenner (1) that *Botryosphaeria Ribis chromogena* (as well as the non-parasitic form) occurs in this country as a fruit rot of apples. If, then, this very definite and constant parasitic form occurs on hosts so unrelated as currant, horse-chestnut, and apple, it seems only natural to find that the saprophytic form also has a wide host range.

With *Physalospora malorum*, the writers have made few inoculation experiments, nor does it appear that much could be gained by so doing. Paddock (4) proved twenty-five years ago that *Sphaeropsis malorum* from persimmon (*Diopyros virginiana* L.), sumach (*Rhus typhina* L.), bitter-sweet (*Celastrus scandens* L.), choke-cherry (*Prunus virginiana* L.), hop hornbean (*Ostrya virginica* Willd.), mulberry (*Morus alba* L.), European plum (*Prunus domestica* L.), and elder (*Sambucus canadensis* L.) would produce a characteristic rot of apples and while this may by no means be taken as proving that the fungi are identical it at least suggests that host differences alone can have little

value in dealing with this species, either as regards its taxonomy or its control.

The work of Hesler (3) largely confirms that of Paddock, and proves that cultures of *Sphaeropsis malorum* from such hosts as mulberry (*Morus alba*), maple (*Acer spicatum*), and elm (*Ulmus americana*) are able to infect apple bark in the manner characteristic of *Sphaeropsis malorum* from apple itself. Hesler also calls attention to the rather remarkable fact that even as late as 1908 and 1909 it was seriously questioned whether the forms occurring on the bark, fruit, and leaves of apple were indeed one species.

The only course consistent with the information now available seems to be to refer to a single species, the material here called *Physalospora malorum* and other material having similar morphological characters, regardless of the host on which it is found. This does not mean of course that but a single species of *Physalospora* occurs on any particular host in this region. There are certainly two and probably several more, but they are not, so far as the writers have thus far observed, limited to a single host or group of hosts.

#### SUMMARY

*Botryosphaeria Ribis* is here reported from seventeen host species and *Physalospora malorum* from twenty-two host species in the eastern United States.

Pycnospores have been produced in pure cultures from single ascospores from each of these hosts.

Throughout this host range both species show remarkable uniformity in the size of their ascospores, the type of germination of the ascospores and in cultural characters on different media. Pycnospores, whether produced in culture or on the host, also show great uniformity.

The size of the sporocarps in both species varies with the thickness and character of the host bark.

The distinguishing characters of the two species, already pointed out in connection with our studies of these fungi on currant and apple, remain constant for all these hosts.

Ascospores of *Botryosphaeria Ribis* are constantly smaller than those of *Physalospora malorum*. Ascospores of *Botryo-*

*sphaeria Ribis* on germinating develop a short branched germ tube while those of *Physalospora malorum* develop a long unbranched germ tube. The pycnidial stage of *Botryosphaeria* is a *Dothiorella* while the pycnidial stage of *Physalospora* is a *Sphaeropsis*. Perithecia and pycnidia of *Botryosphaeria* generally occur in a stroma, while those of *Physalospora* have little, if any, surrounding stromatic tissues.

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#### EXPLANATION OF PLATE 9

Cut perithecia of *Botryosphaeria Ribis* on (A) *Liriodendron*, (B) *Quercus*, (C) *Amygdalus*, (D) *Salix*, and (E) *Melia*.  $\times 8$ .

Cut perithecia of *Physalospora malorum* on (F) *Liriodendron*, (G) *Quercus*, (H) *Amygdalus*, (I) *Salix*, and (K) *Melia*.  $\times 8$ .



# MYCOLOGICAL NOTES FOR 1923<sup>1</sup>

L. O. OVERHOLTS

(WITH PLATES 10, 11)

## 1. MERULIUS RUGULOSUS Berk. & Curt.

Dr. Burt lists this species as occurring in Cuba and Jamaica. In January, 1923, an abundant collection was made at Miami, Fla., by Mr. L. W. Nuttall. The determination was made by Dr. Burt. This is an elegant species, though more likely to be referred to *Phlebia* than to *Merulius*, since both in coloration and in the character of the hymenium it might be mistaken for a bright-colored form of *Phlebia radiata*. The unevenness of the hymenium is not in radiating ridges even in the youngest specimens, as is characteristic of that species, yet that character is likely to be obscured where several small fructifications are confluent. The color of the hymenium is a beautiful ochraceous salmon (Ridgway).

In sections (Plate 10, fig. 4) the gleocystidia are the characteristic structures, filled as they are with a golden oily substance. In many parts of the fructification there are many large imbedded crystals on the upper side of the subhymenial region.

## 2. POLYPORUS FRUTICUM Murrill.

This species, reported by Murrill as found in Cuba, was collected by Mr. L. W. Nuttall at Miami, Fla.

## 3. PORIA AMBIGUA Bres.

An extended description of this species was given in one of my recent papers. Specimens have since been received from Meadville, Pa., from Taylor's Mills, Ga., from Fargo, N. D.,

<sup>1</sup> These notes on new and little known fungi are a continuation of similar short papers begun in 1919 and published for that year in *Mycologia* 12: 135-142. 1920; for the year 1920 in *Bull. Torrey Club* 49: 163-173. 1922; and for the years 1921-22 in *Mycologia* 16: 1924.

Contribution from the Department of Botany, The Pennsylvania State College, No. 47.

and from Corvallis, Oregon. These localities each add a new state and extend the known range of this species very considerably. One of these collections was taken from *Ulmus*—an extension of the host range also.

4. *CINTRACTIA JUNCII* (Schw.) Trel.

This species was collected in abundance at Tolland, Colo., alt. 9000 ft., July 17, 1923, by C. M. Roberts, on a species of *Juncus*. I had not found it in my previous collecting in that state and it is not contained in Dr. Kauffman's recent extensive list.<sup>2</sup>

5. *DICTYOPHORA RAVENELII* (Berk. & Curt.) Burt.

Over a period of several years there have been noted in the vicinity of State College, in situations favorable to the growth of this species, particularly in old sawdust piles, small tuber-like sclerotia of a delicate pink color and connected by conspicuous strands of mycelium. When these were first found they were sectioned in order to obtain a clue to their identity but they were found to be solid masses of parenchymatous or pseudo-parenchymatous tissue. These bodies were sometimes found in the spring of the year and sometimes in early autumn, but it was not until October, 1923, that Mr. C. M. Roberts brought in specimens (Plate 11, fig. 5-6) that showed unmistakably the organic connection between these sclerotia and the fruiting bodies of *D. Ravenelii*.

In size these sclerotia vary from those (probably just beginning to develop) scarcely more than 1 mm. in diameter to others of a maximum diameter of about 1 cm. and a maximum length of about 3 cm. As shown in the illustration, these larger and more elongated forms are characteristically constricted and lobed, and show the definite connection between the sclerotia and the developing eggs. In fact the small egg in fig. 6 has a slight suggestion of having developed directly from one of these sclerotia, though such is probably not the case. Some of the more mature eggs were kept in moist chambers until they expanded into the characteristic fructifications of *D. Ravenelii*, though this fact had already been surmised from finding such fructifications

<sup>2</sup> Kauffman, C. H. The mycological flora of the higher Rockies of Colorado. (Papers Mich. Acad. Sci. 1: 101-150. 1921.)

developed along with the sclerotia in the field. The consistency of these sclerotia is about that of similar tuberous bodies developed by other plants, being rather watery and somewhat fleshy. On drying, however, they become as hard and horny as do the eggs of this species when they are dried. I have not found in the literature of this species previous reference to these bodies.

#### 6. *HELVELLA INFULA* Schaeff.

The half dozen previous collections that I had made of this species were made in the months of May and June, and always on the ground. At Charter Oak, Pa., on October 5, 1923, a *Helvella* (Plate 10, fig. 1) was found growing on a water-soaked, though not badly rotted, log of hemlock. The specimen was sent to Dr. Seaver who pronounced it *H. infula*. I find no previous record of its occurrence so late in the year or on such a substratum, though in exceptional years some related spring species are likely to reappear in the autumn.

#### 7. *SPHAERONEMA ACERINUM* Peck.

Pycnidia columnar, elongate, or finger-like, erect, 1-2 mm. high,  $\frac{3}{8}$  to  $\frac{1}{4}$  mm. diameter though narrowed to a point above, the base buried in the outer layers of the woody cortex, erumpent, externally white pruinose or granular-incrusted, weathering to sordid or almost black, drying hard and brittle; ostiole not apparent; internally with a large elongated cavity extending well to the base of the column, lined with conidiophores, the wall composed of thickly arranged, vertical, branched hyphae, of which the outer layers are brown in color and more loosely arranged and studded externally more or less with calcareous-appearing matter; conidiophores simple, about 30  $\mu$  long, 2-3  $\mu$  diameter; spores oblong or short cylindric, hyaline, one-celled, 17-20 x 5-6  $\mu$ .

Bursting through the bark of dead poles of *Acer rubrum*. Stone Valley, Huntingdon Co., Pa., Sept. 30, 1923. *Overholts 8846*. (Plate 10, fig. 2-3.)

This species was originally described by Peck from three localities in New York state. My collection was determined by Professor Dearnass.

8. *Mycosphaerella smilacicola* (Cooke) comb. nov.

Perithecia mostly epiphyllous, a few hypophyllous, black, rather abundant, globose or subglobose, 75–105  $\mu$  diameter, imbedded in the mesophyll of the leaf, finally barely rupturing the epidermis; perithecial wall black, cellular, 8–12  $\mu$  diameter, 3 to 4 cells thick; asci clavate-cylindric, mostly with acutely pointed tips, 30–40  $\times$  8–10  $\mu$ ; spores 8 per ascus, mostly obliquely uniseriate, clavate or cylindric-clavate, two-celled, one cell usually narrower than the other, hyaline, 15–18  $\times$  3.5–4  $\mu$ ; paraphyses absent.

On leaves of *Smilax*; occupying definite rounded dead spots, 5–12 mm. in diameter, the spots brown in color, with a raised purplish or deep red-brown marginal band 0.5–1 mm. wide. Taylor's Mills, Ga., May 19, 1922. J. C. Dunegan 612. *Overholts* 9203. (Plate 11, fig. 7, 8.)

The history of this species is slightly confusing. Schweinitz<sup>3</sup> originally described it as *Sphaeria smilacicola* and reported it as on the leaves of *Smilax rotundifolia* in Pennsylvania and South Carolina. However, he had previously described<sup>4</sup> another fungus under the same name as occurring on *Smilax* stems. This latter fungus is now referred to *Diatrype* and is entitled to the specific name *smilacicola*. Cooke<sup>5</sup> later described what is apparently the present species as *Sphaerella smilacicola*. *Sphaeria smilacicola*, therefore, as applied to the leaf fungus becomes a homonym, but fortunately Cooke's description of the same species as *Sphaerella smilacicola* allows the specific name to be retained unless it is antedated by some other. For the old generic name *Sphaerella*, *Mycosphaerella* would now be substituted. Apparently Cooke had before him numbers 95 and 155 of Ravenel's *Fungi Americani* when he studied this species. Yet these can hardly be considered as authentic specimens of Schweinitz's species. Ellis and Everhart<sup>6</sup> report that the types of Schweinitz as preserved at Philadelphia are sterile with no perithecia developed. This is an additional reason for basing the species on Cooke's description in *Grevillea*.

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<sup>3</sup> Trans. Am. Phil. Soc. 4: 226. 1834.

<sup>4</sup> Trans. Am. Phil. Soc. 4: 196. 1834.

<sup>5</sup> *Grevillea* 6: 129, 146. 1878.

<sup>6</sup> North American Pyrenomycetes, 747. 1890.

## EXPLANATION OF PLATES

## PLATE 10

Fig. 1. Photo,  $\times 5\frac{1}{7}$ , of ascocarp of *Helvella infula*. Overholts 8774.

Fig. 2. Low power microphoto of free-hand vertical section through the columnar pycnidium of *Sphaeronema acerinum*, showing the internal cavity continuous to near the base of the column. The tip of the column has become recurved in sectioning. Overholts 8846.

Fig. 3. High power microphoto of a small portion of the same section shown in Fig. 2, showing the construction of the pycnidial wall, lined internally with conidiophores producing the oblong conidia.

Fig. 4. Microphoto of a free-hand vertical section through the fructification of *Merulius rugulosus*. Overholts 8682.

## PLATE 11

Fig. 5. Photo,  $\times 1$ , of a sclerotium and an egg of *Dictyophora Ravenelii*, with a mycelial strand connecting them. Overholts 8793.

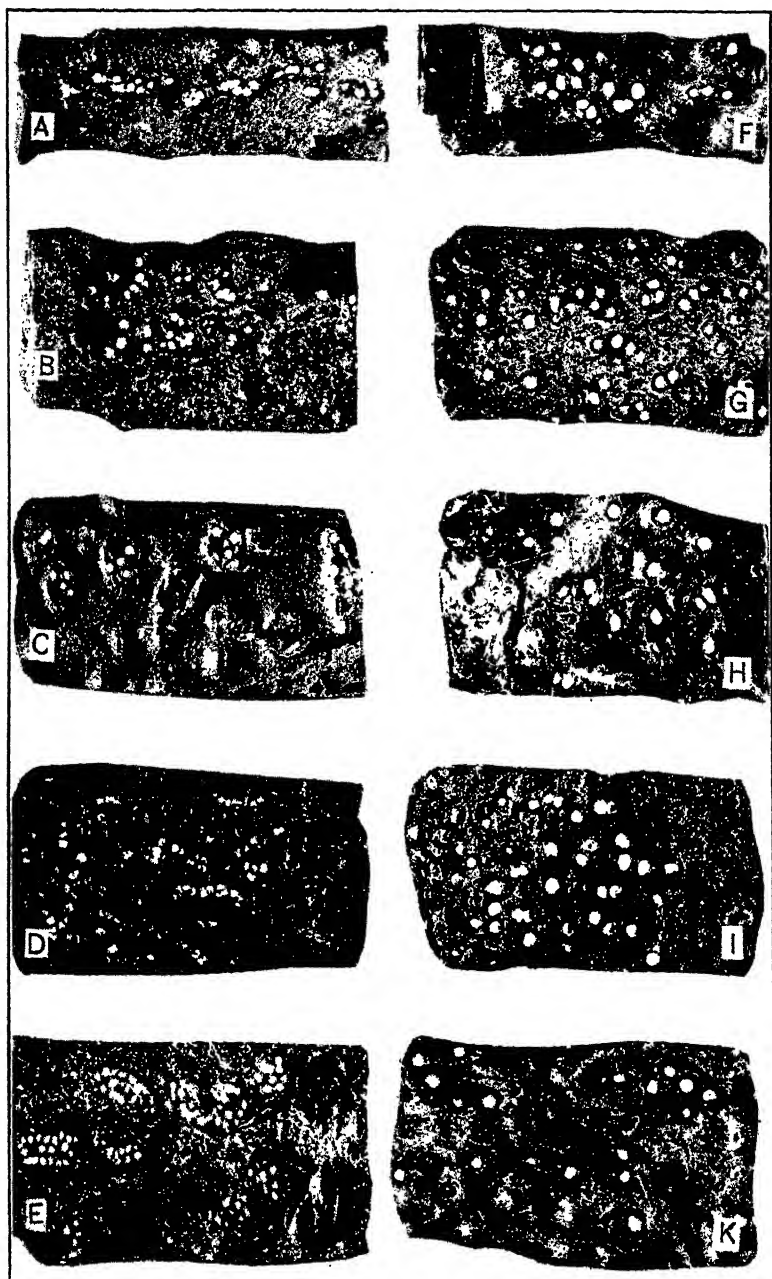
Fig. 6. Photo,  $\times 1$ , of several sclerotia of *Dictyophora Ravenelii* connected by mycelial strands. Also in the upper right hand corner a small egg of the same species.

Fig. 7. Ascospores of *Mycosphaerella smilacicola*.

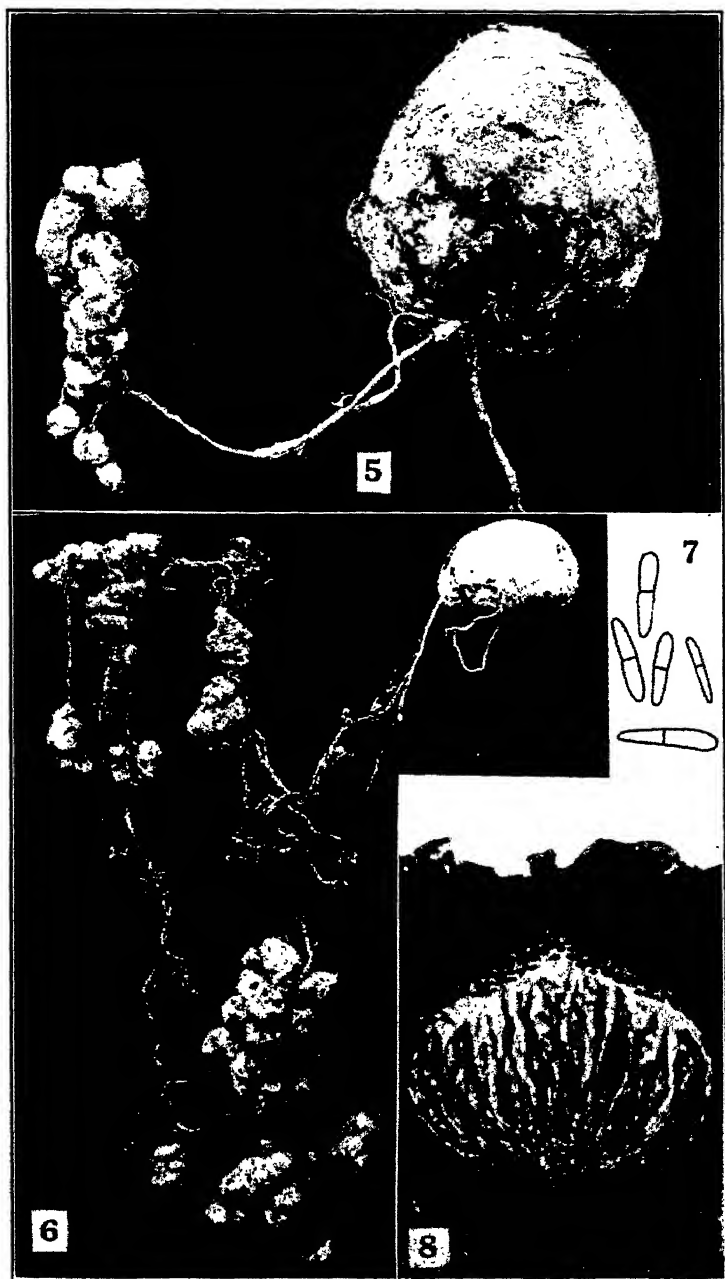
Fig. 8. Microphoto of a free-hand section through the perithecium of *Mycosphaerella smilacicola*. Overholts 9203.



1 *HELVELLA INFULA* 2-3 *SPHAERONEMA ACERINUM* 4 *MERULIUS RUGULOSUS*



BOTRYOSPHAERIA AND PHYSALOSPORA



5-6. *Dictyophora ravenelii*. 7-8. *Mycosphaerella smilacicola*





## THE GENUS GOMPHIDIUS IN THE UNITED STATES <sup>1</sup>

C. H. KAUFFMAN

(WITH PLATES 12-14)

I reviewed the salient characteristics of the genus *Gomphidius* in the introduction to the genus in the Agaricaceae of Michigan, 1: 170 (8). At that time only a few species had come to my notice in the field in this country, although I had seen *G. viscidus* Fr. and *G. glutinosus* Fr. growing in abundance in northern Europe. In European countries only four species of this genus are usually recognized in floras: *G. viscidus* Fr., *G. glutinosus* Fr., *G. roseus* Fr. and *G. maculatus* Fr. The British mycologists, however, report, in addition to these species, also *G. gracilis* Berk., and Rea (12) says the latter is "common" in fir woods and heaths. Recent accounts of the American species of this genus have been published by Murrill (9 and 10).

The species of this genus usually possess a viscid or glutinous, and hyaline, universal veil; in some species, however, this veil is dry or merely moist, developing a slight viscosity only in very wet weather. The glutinous veil surrounds the young button, in the same manner as in the subgenus *Limacium* of the genus *Hygrophorus*; in the subgenus *Myxacium* of the genus *Cortinarius*; and in certain other genera of the Agaricaceae. In a few species, this veil is scarcely or not at all evident, although it is possible that even in these a blematogen is present in the early stages. In most species this veil forms a definite teleoblema as is shown by the fact that it is separable from the pileus as a distinct, thick pellicle. Confusion may easily arise concerning the color of the universal veil, because of its tendency to become black in a number of the species. Berkeley says (2) the pileus of *G. gracilis* Berk. "is covered with a smoke-colored gluten." However, the veil of this species, like that of a number of others,

<sup>1</sup> Papers from the Department of Botany of the University of Michigan, No. 221.

doubtless blackens easily when touched or in age, and in the fresh condition it is likely that the gluten is hyaline. Dr. Peck kept this distinction in mind when he described *G. nigricans* Peck (11) with its sensitive gluten. After giving the color of the pileus as "pale brownish-red," and that of the stem as "whitish," he says: "The species is usually known by the blackening gluten which smears both pileus and stem. . . . In the dried state the whole plant is black." The degree of blackening of the surface of the pileus and stem is much used in the descriptions of the species of this genus, but it is often difficult in an examination of dried plants to apply statements concerning it, because of the extreme blackening that may occur due to overheating. On the other hand, this character is of great help in discriminating between certain species when they are properly dried. Since the blackening of cap and stem is due to the veil, it is at once evident that rain-washed plants may not show this reaction after the specimens have been dried. Certain species, however, when in growing condition, do not dry black when properly dried. Such are *G. tomentosus*, *G. furcatus*, *G. subroseus* and *G. viscidus* forma *columbiana*; others like *G. ochraceus*, *G. maculatus* and *G. glutinosus* show this characteristic in greater or less degree, while *G. nigricans* shows it to an extreme extent.

A cortina-like partial veil, more or less continuous on the inside of the universal veil where the latter passes over the gill area, is present in most and perhaps in all species in the young condition; it is never copious and is soon evanescent.

The *gills* are decurrent, subdistant or distant; in only one species, viz., *G. vinicolor* Peck, can the gills be said to be close. The type of this species at Albany clearly has closer gills than is usual, but whether this character is consistent in the fresh plant is not too certain. Poor, small or undeveloped specimens of the other species sometimes give the effect of "close" gills.

The color of the gills changes markedly during the development of the spores. If one could make a color chart of these changes for each species, I am convinced that the shades of color represented would be quite specific for each species. I have taken down these shades of color at the time of collecting the fruit-bodies and found that even in the same region and with the

same undoubted species, I would get such a variety of Ridgway color names as to be more confusing than helpful. This is due to the fact that one necessarily collects the plants at different stages of maturity. Giving a general color description seems to be the only useful procedure, but even thus, the specific differences can be brought out. It is desirable to obtain the color of the gills before the fruit-body is overmature, because the very mature gills of the different species may be much alike. For example, the gills of *G. furcatus* Peck are "testaceous" (Ridg.) at a certain stage, and those of the new form, *G. viscidus* described in this paper, are "tawny" and later "sepia" in color. The European species *G. glutinosus* and *G. viscidus* should be distinguishable by their gill-color according to the emphasis (in italics) usually placed on the colors given, but unfortunately there is no exact agreement among European mycologists; and as explained above, this is not surprising when not all the stages are given. Reading between the lines, it seems evident that the prevailing color of the gills of *G. glutinosus* is some shade of gray, while those of *G. viscidus* tend to have tawny shades which become clouded with olivaceous or purplish hues.

The gill-trama is said by Fayod (4) to be divergent ("bilateral"). My own records are not complete for all of the species, but in my collection of *G. glutinosus* in Idaho, the gill-trama was composed of interwoven floccose hyphae of large cells. The texture of the gill-trama is quite mucilaginous and tends to disintegrate.

The spores of all the species of *Gomphidius* known are elongated, fusiform or subfusiform to subcylindrical, and generally large in size. The largest spores were reported by Dr. Peck for his species *G. flavipes*; the maximum length recorded by him was 30  $\mu$ . In examining the type, which was dried too hard and is not very satisfactory, I found enough spores measuring 25  $\mu$  in length to make it very probable that the extremes are 30  $\mu$ . The color of the epispore as seen under the microscope can best be called sooty varying in intensity in different species or during different stages in the maturity of the spores. In some species the epispore appears punctate under high magnification.

In Fayod's account (4) of the generic characteristics of *Gomphidius*, due attention was given to the *cystidia*, which other authors since then have all too often neglected. These remarkable structures, cylindrical, large, and protruding markedly above the hymenium, Fayod considered as a unique means of distinction, separating this genus from all the others. As seen from the synopsis following, he was nearly correct; only *G. oregonensis* Peck and *G. nigricans* Peck have so far been examined by me in which the hymenium either lacks these characteristic cystidia or relatively few occur. Atkinson (1), in his account of *G. nigricans*, does not mention any cystidia although I was able to locate a few in my own examination of his material. There is little doubt that Atkinson had the true *G. nigricans*. In all my mounts of Peck's type material, I was unable to locate any cystidia.

Fayod, in his description of the cystidia (l.c.), mentions a crust-like covering over the main body of the cystidium, and illustrates this characteristic in his figure of the cystidia of *G. viscidus* (Pl. 6, fig. 7b). In the figure referred to, this crust appears to be of a crystalline nature. Neither Ricken (13) nor Rea (12) mention this peculiarity of the cystidia in the European species, although the cystidia are described by these authors. In all the material which I have examined, which included most of the species in the fresh condition as well as all of the American type collections, I have rarely seen anything approaching Fayod's figure. The cystidia are extremely abundant in some species and hence such a character should be easily seen. However, occasionally one does find a sort of sheath, of a somewhat roughened or crystalline character, but normally the wall is entirely smooth. Therefore I am inclined to consider this encrusted condition a fleeting or developmental condition, not to be used as a specific character.

The relationship of the genus *Gomphidius* is not very clear. In the opinion of Fries (Monographia 1: 149) "they have the stature of *Limacium*, but seem to hold closest relationship with *Cortinarius*, from which, nevertheless, they are far removed by the nature and color of their spores" (7). In *Hymenomycetes Europaei* (6), p. 399, he placed the group between *Cortinarius* and *Paxillus*.

Fayod (4) argues for a relationship between *Gomphidius* and *Paxillus* and includes both these genera in his tribe Paxillés. He, as well as others, laid a foundation for his argument by keeping Schweinitz's American species "*Agaricus rhodoxanthus*" (14) in the genus *Gomphidius*. This plant has been fully discussed by Atkinson (1) who places it in *Paxillus*, where I have hitherto kept it. In passing, it may be well to point out that it has a much closer relationship to some of the American species of *Boletinus*, and might well be put into that genus, disregarding its gill characters (the gills sometimes anastomose), and taking into account its habit, texture, spores and cystidia as of more relationship value than the gills. Such a situation has arisen with regard to the species of *Lenzites*, and a number of mycologists now agree to attach the latter genus to the Polyporaceae, a procedure which seems to me thoroughly scientific. Fayod (l.c.) pointed out the similarities of the Schweinitz plant with species of *Boletus*, especially with *B. subtomentosus* Fr., but as far as I know no one except Battaille (*Les Bolets*, p. 24, 1908) has definitely placed it in that group. The plant should be called *Phylloporus rhodoxanthus* (Schw.) Bres. (3), and placed next to the genus *Boletinus* in the Boletaceae.

Ricken has grouped *Gomphidius* with *Hygrophorus*, indicating its relationship with the subgenus *Limacium* of that genus, a disposition which I have followed (8), and which seems to me to have much in its favor. The structure of the veils, pileus, stem and gills are practically alike in certain species of *Hygrophorus* and of *Gomphidius*, the outstanding difficulties being the necessity of accounting for the characteristic cystidia and spores of the latter. But I can see no other connection where the difficulties are not more numerous. Rea (12) has placed it next to and presumably "above" the genus *Flammula*, but this arrangement seems to me entirely unsupportable.

Our species are found practically always in the neighborhood of coniferous trees, often in sphagnum bogs or in deep moss in the forest. Collections are made infrequently except in the northwestern Pacific coast states, where several species are quite abundant.

I wish to express my obligations to the authorities of the

New York Botanical Garden and to Dr. House of the New York State Museum for the privilege of access to the types of Dr. Merrill and Dr. Peck; also to the Department of Plant Pathology of Cornell University for allowing me to examine all of the specimens in the Atkinson herbarium.

SYNOPSIS OF THE SPECIES OF GOMPHIDIUS OCCURRING IN THE NORTH  
TEMPERATE REGIONS

1. Cystidia few or lacking; plants becoming black when dried. (*G. glutinosus* may be sought here)..... 2
1. Cystidia present and more or less abundant, long and cylindrical. .... 3
2. Spores 15-22 x 5.5-6.5  $\mu$ ; pileus 2-7 cm. broad, not umbonate, glutinous, pale brownish-red when fresh; eastern U. S. (See figs. 50 and 51, Atkinson 1)..... *G. nigricans*.
2. Spores 10-13 x 3.5-4.5  $\mu$ ; pileus 5-10 cm. broad, not umbonate, viscid, livid flesh-colored when fresh, becoming black-spotted; stem citron-yellow below..... *G. oregonensis*.
3. Pileus with ochraceous shades, at least when young and fresh; western U. S..... 4
3. Pileus not noticeably of these colors..... 5
4. Pileus glabrous and glutinous; spores 15-19 (22) x 6-7  $\mu$ . (See description)..... *G. ochraceus*.
4. Pileus densely floccose-tomentose, dry or nearly so; spores 17-21 (24) x 6-9  $\mu$ ..... *G. tomentosus*.
5. Pileus 5-10 (12) cm. broad ..... 6
5. Pileus 2.5-5 (6) cm. broad ..... 7
6. Pileus convex to plane, not umbonate, glutinous, livid purplish-brown; gills at first whitish, becoming gray to blackish at maturity; cystidia few to scattered; spores 17-22 x 6-7  $\mu$ ..... *G. glutinosus*.
6. Pileus with subconic umbo, only slightly viscid, dark vinaceous-red to dark reddish-brown; gills at length olivaceous to purplish-umber; cystidia abundant; spores 17-20 (21) x 6-7.5  $\mu$ ..... *G. viscidus*.
7. Stem with yellow base or yellow more or less throughout, concolorous within..... 8
7. Stem not yellow..... 12
8. Pileus 2.5-6 (7) cm. broad ..... 9
8. Pileus 1-2.5 cm. broad, convex-plane, pink, with white flesh; gills distant; spores 22-25 (30) x 6-7.5 (8)  $\mu$ ..... *G. flavipes*.
9. Gills more or less forked..... 10
9. Gills not forked or very rarely; stem remaining dull red and pileus sooty-red when dried; pileus with subconic umbo; spores 16-21 (23) x 6-7 (7.5)  $\mu$ . (See description)..... *G. viscidus* forma *columbiana*.
10. Pileus not umbonate; stem 6-12 mm. thick..... 11
10. Pileus umbonate, pale vinaceous-brown when fresh, gluten becoming smoky; stem 3-6 mm. thick; spores 16-19 x 5-7  $\mu$  (Rea)..... *G. gracilis*.
11. Stem sheathed by the viscid veil, white upwards and remaining whitish when dried; pileus salmon-colored to vinaceous-pink; spores 14-17 (20) x 5-6  $\mu$ . (See description)..... *G. subroseus*.

11. Stem not sheathed, at length becoming black-stained or blackish when dried: veil lacking or obsolete; pileus brownish-incarnate, at length black-stained; spores  $15-23 \times 6-7.5 \mu$ . *G. maculatus*.
12. Gills distinctly forked; stem attenuate downwards or pointed at base. 13
12. Gills not forked, close; pileus dark red; stem vinaceous-reddish, not pointed at base; spores  $17-22 \times 5.5-6.5 \mu$ . (Type) *G. vinicolor*.
13. Spores  $15-17 \times 4-5 \mu$  (Rea); pileus rose-colored; stem whitish, tinged rosy at base; gills whitish-cinereous, finally olivaceous. *G. roseus*.
13. Spores  $16-21$  (24)  $\times 5-6.5$  (7)  $\mu$ ; pileus at first whitish, then "testaceous" (R.); stem white, becoming pinkish; gills whitish, becoming testaceous, at length variegated with sooty-brown *G. furcatus*.

## UNDESCRIBED AND EMENDED SPECIES

### *Gomphidius ochraceus* sp. nov.

Pileus 3-6 cm. broad, convex-expanded then plane, *glabrous*, *glutinous*, "ochraceous-salmon" to "apricot-orange" (Ridg.) when fresh, soon clouded with "olive-brown" and gradually becoming tinged with vinaceous shades, even or soon rugose-wrinkled from the drying gluten, margin at first incurved, at length spreading: flesh thick, abruptly thin on margin, whitish to "pinkish-buff." Gills decurrent, subdistant to distant, rather broad, 7-8 mm., "tawny" (Ridg.), thick, edge entire. Stem 8-10 cm. long, tapering downwards, 6-10 mm. thick at apex, variously curved, subviscid, solid, "orange-buff" to "zinc-orange" (Ridg.), more or less floccose upwards to an obsolete annulus, concolorous within. Spores ellipsoid-fusiform,  $15-19$  (22)  $\times 6-7$  (8)  $\mu$ , smooth, pale smoky. Cystidia abundant, cylindrical, hyaline, rounded-obtuse at apex,  $150-180 \times 12-15 \mu$ . Odor none. Taste mild. Closely gregarious.

On deep moss under conifers, near Welch's Post Office, Oregon National Forest, Mt. Hood, Oregon. September 29, 1922. Collected by C. H. Kauffman. Type in the herbarium of the University of Michigan.

This species has such a superficial similarity to *G. tomentosus* Murrill that it is easily passed by as that species. It differs definitely, however, in its glabrous and glutinous pileus, and in its somewhat broader and more distant gills. *G. tomentosus*, which was abundant in this region, and was carefully studied, does not have what I should call "distant" gills as given in Murrill's description; rather the gills are close to subdistant. The color is not very sharply different, but a difference does show whenever the fresh plants are compared. The subviscid stem indicates a thin and evanescent universal veil.



**Gomphidius subroseus** sp. nov. (Plate 13).

Pileus 3-6 (7) cm. broad, convex-expanded then plane, very obtuse to broadly depressed, with a viscid separable pellicle, glutinous only in rainy weather, varying "salmon-color" to "vinaceous-pink" (Ridg.), disk "ochre-red" to "testaceous," usually fading, becoming slightly blackish on drying, glabrous, even or slightly wrinkled when dry; flesh thick on disk, abruptly thin on margin, white or tinged vinaceous. Gills decurrent, close to subdistant, attenuate at ends, 6-7 (8) mm. broad at middle, soon "pale smoke-gray" to "pale mouse-gray," finally darker and variegated, some forked near margin or towards stem, thickish, edge entire. Stem 3-6 cm. long, 6-12 (15) mm. thick, tapering downwards or subequal, straight or curved, solid, base or lower half "lemon-yellow," "empire-yellow" or "citron-yellow" (Ridg.), apex or upper portion white and silky, covered when fresh up to near the apex by the hyaline, viscid, thin, appressed sheath of the universal veil, at length glabrous and dry, rarely becoming sordid or blackish in age. Spores 14-17 (20)  $\times$  5-6  $\mu$ , subfusiform-ellipsoid, obtuse at ends, smooth, dark sooty. Cystidia rather abundant, cylindrical above the slender pedicel, hyaline (in fresh plants), 100-140  $\times$  8-15  $\mu$ , apex rounded. Odor and taste none.

Type on humus and moss under conifers, near Welch's Post Office, Oregon National Forest, Mt. Hood, Oregon. September 22, 1922. Frequent in this region. Also under pines, Tolland, Colorado, September 14, 1920; and near Copeland, Idaho, September 2, 1922. Collected by C. H. Kauffman. Deposited in the herbarium of the University of Michigan.

This species differs from *G. roseus* (Fr.) Quél. by the distinct yellow base of the stem, by the less rosy-red color of the pileus attributed to the European plant, and perhaps by the cystidia. We apparently have no account of the cystidia of *G. roseus*. Ricken, to be sure, gives cystidia for the plant he places under that name, but Ricken's description departs from the conception of other mycologists, and his plant may be the species here described, or perhaps it is *G. gracilis*. Rea (12) unaccountably copies Ricken's remarks on the cystidia, but Rea's description otherwise applies to the plant with a rosy stem-base, and is therefore to be considered the correct traditional conception of *G. roseus*.

*G. gracilis* Berk., although it has a yellow stem-base, is described by Berkeley as having a conic-hemispherical pileus and

others agree that it is more or less umbonate; *G. subroseus* has a rounded pileus from the beginning and later becomes plane to depressed. After the specimens were dried they turned somewhat blackish, but when fresh this tendency to blacken—so noticeable a characteristic in some species—is very slight in this western species. From *G. flavipes* it is readily distinguished by its smaller spores, and from *G. maculatus* by the veil on the stem.

GOMPHIDIUS OREGONENSIS Peck (emended).

Pileus 5–10 cm. broad, at first convex, obtuse, becoming plane, glutinous from the universal veil, livid flesh-colored when fresh, becoming black-spotted in age and blackish when dried, glabrous, even; margin at first incurved. Gills short-decurrent, close to subdistant, gray when partly mature, then blackish. Stem 3–8 cm. long, subequal or tapering downwards, rather stout, 8–15 (25) mm. thick, floccose-fibrillose, citron-yellow almost to the apex, sheathed in part by the glutinous veil which sometimes terminates in a glutinous ring near the apex, yellow within at the base, surface becoming black-spotted when handled. Odor and taste mild. Spores narrow, elongated-ellipsoid,  $10\text{--}13 \times 3.5\text{--}4.5 \mu$ , smooth, tinged smoky. Cystidia few, subcylindrical,  $100\text{--}125 \times 15\text{--}18 \mu$ .

Description drawn from fresh plants collected at Lake Cushman, Washington, 1915, by C. H. Kauffman.

This has much the habit and stature of *G. glutinosus*, but is definitely distinct by its relatively small spores, and the somewhat different colors when fresh. The glutinous veil is quite thick on the pileus and especially so on the incurved margin of the young fruit-body. It is reported from all the Pacific coast states.

This species was incompletely described by Dr. Peck, who apparently drew his description from dried plants. Few collections are in the eastern herbaria that I examined. The specimens from California, distributed under this name by C. F. Baker in "Pacific Coast Fungi, No. 155," is not a *Gomphidius*, but probably a *Paxillus* with globose spores—at least this is true of the copy in the Atkinson herbarium. On the printed label of this number, Baker states that the gills are phosphorescent, a statement which is therefore not dependable in its application to *G. oregonensis* (9).

Dr. Lane of Portland, who sent the specimens from which Dr. Peck drew his description, wrote Dr. Peck that this species "grows there by the wagon load." Murrill (l.c.) says he "found it common both in Washington and Oregon." Zeller (15) also reports it as "one of the very common Agarics" around Corvallis, Oregon. My experience differs for the localities I visited in Washington and Oregon. At the base of Mt. Hood, *G. tomentosus* was very abundant, and rarely one could pick up also a few specimens of *G. ochraceus* and *G. subroseus*. In the Cascade range east of Seattle, only *G. tomentosus* was found. In northern Idaho the latter species also occurred. In the Olympic Mountains, however, in addition to the frequent *G. tomentosus*, I obtained two solitary-growing specimens of *G. oregonensis*. The questions then arise, is it *G. tomentosus*, instead of *G. oregonensis*, which is so common in these regions, or is each common only in certain localities? The simple process of determining the spore-size will doubtless be sufficient in the future to decide these points.

**GOMPHIDIUS VISCIDUS** Fr. **columbiana** form. nov.

Pileus 2-6 cm. broad, at first subconic-campanulate then expanded-umbonate, subviscid, or viscid in wet weather, color when fresh "auburn," "bay" or "Hay's russet" (Ridg.), sometimes with purplish tints, very glabrous, even, shining when dry; margin at first incurved, and cortinate with an evanescent, "apricot-buff" cortina; flesh thick on disk, abruptly thin on margin, tinged pinkish. Gills decurrent, broad in middle, narrowed towards ends, close to subdistant, distinct, none or very few forked, thick, soon "ochraceous-tawny" to "tawny," at length "sepia" or "Prout's brown" (Ridg.). Stem 3-7 (8) cm. long, 4-12 (15) mm. thick, subequal or ventricose downwards, or somewhat pointed at base, solid, varying when young from "capucine-buff," or "flesh-ochre" to "apricot-orange," at length sordid brown, concolorous within, when fresh covered with delicate, appressed fibrillose shreds, glabrescent except at the obsolete cortinate zone at apex, which is colored by the spores. Spores 16-21 (23) x 6-7 (7.5)  $\mu$ , subfusiform, smooth, tinged smoky. Cystidia very abundant, cylindrical, with slender pedicel, hyaline, 120-150 x 15-18  $\mu$ . Odor and taste none.

Description from studies in the field. Collected in the Rocky mountains of Wyoming and Colorado. August and September. The American form of *G. viscidus* differs from the European plants

in the much smaller average size, somewhat different colors, and a tendency to form longer and more truly fusiform spores. Exsiccati from Europe which I examined came from Sweden, France, and the mountains of Italy; some are in the Atkinson herbarium and some at the New York Botanical Garden. When properly dried, the stems of the European form are regularly and conspicuously "ochraceous-tawny" to "cinnamon-brown" (Ridg.). The dried stems of the American form, when not darkened by overheating, are always dull reddish; the caps also become this color but tend to assume darker shades of it. Well-dried plants of the two forms do not "match." This American form occurs definitely throughout the Rocky Mountain and Pacific coast states. Specimens from California slightly larger than usual are in the herbaria mentioned. Whether any of the collections from the eastern United States usually referred to *G. viscidus* actually belong here, I am unable to say.

#### COMMENTS

*GOMPHIDIUS FLAVIPES* Peck.—This must be a rare species. The type specimens, as Murrill (*Mycologia* 14: 125) has already pointed out, are of no value for comparison. The unusually long spores are its principal claim to recognition.

*GOMPHIDIUS FURCATUS* Peck.—Apparently a species of the eastern United States only. It is probable that collections referred at times to *G. viscidus* Fr. belong here. The spores of the type material at Albany vary slightly longer than the length given by Peck. (See synopsis in this paper.) I have found this twice in Maryland, under pines; the pileus of these was 2-7 cm. broad, the stem up to 10 cm. long by 3-10 (12) mm. thick. Peck's plants had more slender stems. The color of the fresh pileus is "testaceous" (Ridg.), of the stem "congo-pink"; after drying the color of both is pale reddish. Small specimens do not always have the gills forked. This species differs from all forms of *G. viscidus* in the absence of yellow in the stem. At Albany, there is a collection by Earle from Alabama, marked "*G. alabamensis* Earle." This is very probably *G. furcatus*. It grew "among needles under pine," has forked gills and the notes say that it was "pale reddish-brown throughout."

GOMPHIDIUS GLUTINOSUS Fr. (Plate 12).—There are good specimens from Bresadola at the New York Botanical Garden, and typical plants from Sweden in the Atkinson Herbarium. The principal point to be brought out here is that the cystidia are not abundant. In fact in some mounts it is difficult to locate them. In overmature and dried plants they are frequently shriveled, so that observations must be carefully checked. The cystidia of this species also appear to be less cylindrical than in many of the others. The caps are usually quite large, and the stems stout and long. It may be said to be the largest species.

GOMPHIDIUS GRACILIS Berk.—I have a few collections from the mountains of Washington which are referable to this species. There are, however, slight differences and further notes are needed. I have seen no European specimens. Our western plants have longer and stouter although rather more slender stems than described for the European species. The spores of the western plants measure  $15-18 \times 5-6 \mu$ , and the cystidia are abundant.

GOMPHIDIUS MACULATUS Fr.—I have found no facts which make it necessary to change my account of this (8, p. 170). The comments given with that description on other species (l.c.) are, however, revised in this paper.

GOMPHIDIUS NIGRICANS Peck.—This is an eastern species, seldom collected. (See remarks on p. 114.)

GOMPHIDIUS ROSEUS (Fr.) Quél.—(See remarks under *G. subroseus*.)

GOMPHIDIUS\* TOMENTOSUS Murrill (Plate 14).—(See remarks under *G. oregonensis*.) The following descriptive data may be added to Murrill's account (Mycologia 4: 307. 1912). Pileus 3-7 cm. broad, obtuse, sometimes actually subumbonate, the thick pellicle separable and slightly viscid in wet weather, "ochraceous-buff" (Ridg.), darker when wet and then "vinaceous-tawny" to "wood-brown" (Ridg.), deeper ochraceous when dry; flesh thick on disk, abruptly thin on margin, whitish to ochraceous, shot through with "pinkish-buff" hues. Gills close to subdistant, 6-8 mm. broad in the middle, "ochraceous-buff" to "ochraceous-salmon" (Ridg.), at length sooty-brown. Stem 6-12 cm. long, 8-15 (20) mm. thick, rather firm and rigid, con-

color, at first floccose, then lacerate-fibrillose or denuded, sometimes slightly viscid; flesh compact, concolorous, "empire-yellow" (Ridg.) towards base. Taste often tardily but slightly disagreeable. Cystidia abundant, cylindrical, with slender pedicel which extends below the hymenium, hyaline, rounded at apex,  $150-180 \times 10-15$  (18)  $\mu$ . variable in length and thickness. In dense coniferous forests of fir and hemlock.

The unique tomentose-hairy surface is due to the thick universal veil which surrounds the young unopened plant. On the stem as it elongates the veil is lacerated, broken into fibrillose shreds or washed off in some cases. Sometimes the portion of it encircling the apex of the stem persists as a floccose-hairy annulus. The inferior veil is fibrillose-silky and concolorous, soon disappearing. The base of the stem is often deeply imbedded in conifer-needle beds or in moss cushions. The spores are as given by Merrill.

*GOMPHIDIUS VINICOLOR* Peck.—The dried type specimens at Albany are distinctly red-brown. A collection in the Atkinson herbarium from Dr. Herbst and collected in Lehigh Co., Pennsylvania, is very probably the same, although the spores average quite a little shorter. The spores of this species are notable for their more ventricose shape and appear much more fusiform under the microscope than most, especially those of *G. viscidus* forma *columbiana* which also dries reddish-brown and of which the spores tend to be subcylindric in shape. I have spoken before (8, p. 171) of the tendency for small or late-growing plants of this genus to have shorter spores than in "normal" plants. Considering that Peck describes the gluten of the pileus as turning black on drying, it is surprising to find the type specimens of this species unblackened, which indicates that the gluten or viscosity is thin and disappears. The species is rare. I should hesitate to refer here the plants from around San Francisco, California, some of which I examined at the New York Botanical Garden. (See *Mycologia* 4: 307.) The form mentioned by me in *Agaricaceae* of Michigan I, p. 171, as form "minor," is a slender little plant and cannot be placed here.

*GOMPHIDIUS VISCIDUS* Fr.—European specimens are well represented in American herbaria. The cystidia are abundant but

perhaps less so than in the American form "*columbiana*." (See remarks under the latter.)

GOMPHIDIUS spp.—One finds occasionally a few specimens rather small and slender, which are hard to place. Whether some of these are undescribed or are abnormal cannot be determined with the material and notes on hand. Two such forms are mentioned in Agaricaceae of Michigan I, p. 171-2. I have others from the Adirondack Mountains, and from North Carolina. The rarity of these, if they are autonomous species, and the chances of finding them when developed under favorable weather conditions or when not too old makes it difficult to "get a line on them."

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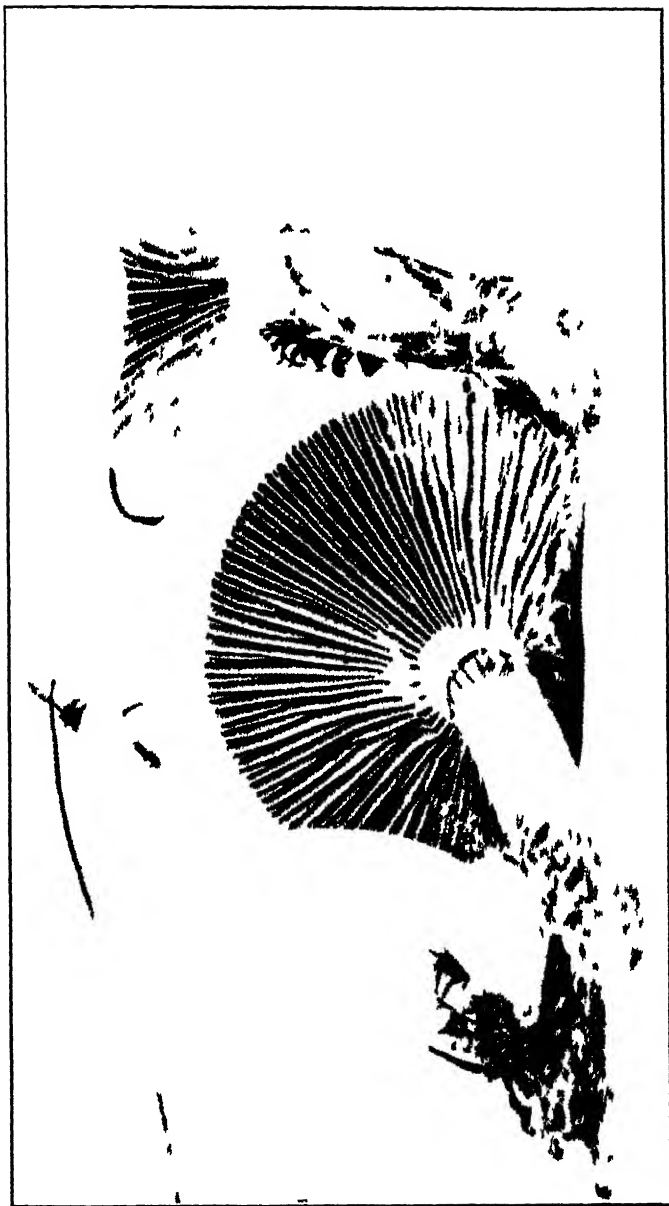
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GOMPHIDIUS CLUNENSIS







Гриб *Boletus*





GOMPHIDIUS TOMENTOSUS



## NOTES AND BRIEF ARTICLES

Professor E. M. Gilbert, of the University of Wisconsin, visited the New York Botanical Garden in February, devoting some time to the study of the collections of the higher fungi.

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Professor H. H. Whetzel, of Cornell University, spent several days during February at the New York Botanical Garden looking over the collections of Porto Rican fungi in collaboration with the latter institution on the survey of the fungous flora of Porto Rico.

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In "Studies in Entomogenous Fungi. V. *Myriangium*" (Trans. Brit. Mycol. Soc. 10: 75) T. Petch makes the following comment on *Myriangium tuberculans* Miles (Mycologia 14: 80): "Miles has recently described *M. tuberculans*, found on *Carya illinoensis*, at Ocean Springs, Mississippi. From specimens with which he has kindly furnished me, this is *M. Curtisii*. The apothecia in the larger specimens are convex, so that the surface is faceted. The tissue is more compact than in the old herbarium specimens, and the stroma consequently less friable, again approaching *M. Montagnei*. The spores are 18-28 x 10-12  $\mu$ , rather larger than in the other available specimens, in which they do not exceed 24 x 9  $\mu$ . The specimens are accompanied by *Microcera coccophila*, the synnemata of the latter arising at the side of, or beneath, the *Myriangium*."

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### COLLECTING AROUND ST. AUGUSTINE, FLORIDA

When the chilly winds began to blow, about the first of December, and the Virginia woods no longer yielded their harvest of mushrooms, my memory turned back to quaint old St. Augustine, nestling among the live-oaks and palmettos on the seacoast forty miles or so southeast of Jacksonville. The journey from Lynchburg required only twenty-five hours, the weather meanwhile becoming notably milder, although the hotel rooms were heated upon my arrival.

Among the fungi, the wood-destroying kinds were more in evidence, since the season for most of the fleshy kinds was practically over. A big red *Flammula*, however, was growing fresh from decayed oak roots, almost equaling some pilei of *Ganoderma Curtisii* in brilliancy. *Geaster* was entirely dried out; but a common species of hard-skinned puffball (*Scleroderma*) occurred in some abundance in all stages, showing an unusually long stem because growing in sand.

On December 6, I drove northward along the west side of the Matanzas River and collected in the groves of live-oak, interspersed with a few magnolia and hickory trees. Here was Spanish moss in abundance and the pretty little resurrection-fern (*Polypodium incanum*) growing in tufts on the oak trunks. Tree-destroying fungi were common, notably *Inonotus hirsutus*, *Ganoderma Curtisii*, *Hapalopilus gilvus* and *licnoides*, *Gloeoporus conchoides*, and several species of *Coriolus* and *Stereum*. *Armillaria mellea* had decayed, but species of *Lactaria*, *Russula*, and *Cortinari* were perfectly new and fresh. I even found one specimen of the dark form of *Venenarius phalloides*.

Turning westward across the San Sebastian River, the live-oaks were left behind and a region of real pineland encountered, with long-leaf pines, palmettos, fan-palms, bracken fern, asters, goldenrod, etc. Here I found the same large *Flammula* seen at North Beach, several specimens of *Russula* different from those growing under the oaks, and beautiful fresh hymenophores of *Tricholoma rutilans*.

I mentioned above that a single specimen of the deadly *Amanita* was found in an oak grove. A few days later, on Anastasia Island, I found quantities of the same species colored nearly white with shades of cream and green on the disk, corresponding exactly to the last crop of the season found at Lynchburg, Virginia, in oak woods. A little distance away, several clusters of a brilliant species of *Flammula* attracted my attention. It is a large southern species partial to live-oak wood. *Pyropolyporus Calkinsii*, *Cerrenella Ravenelii*, *Pycnoporus sanguineus*, and *Pogonomyces hydroides* were also found in the same locality under oaks and *Gloeophyllum Berkeleyi* on pine wood.

Near the great alligator farm on this island, I discovered



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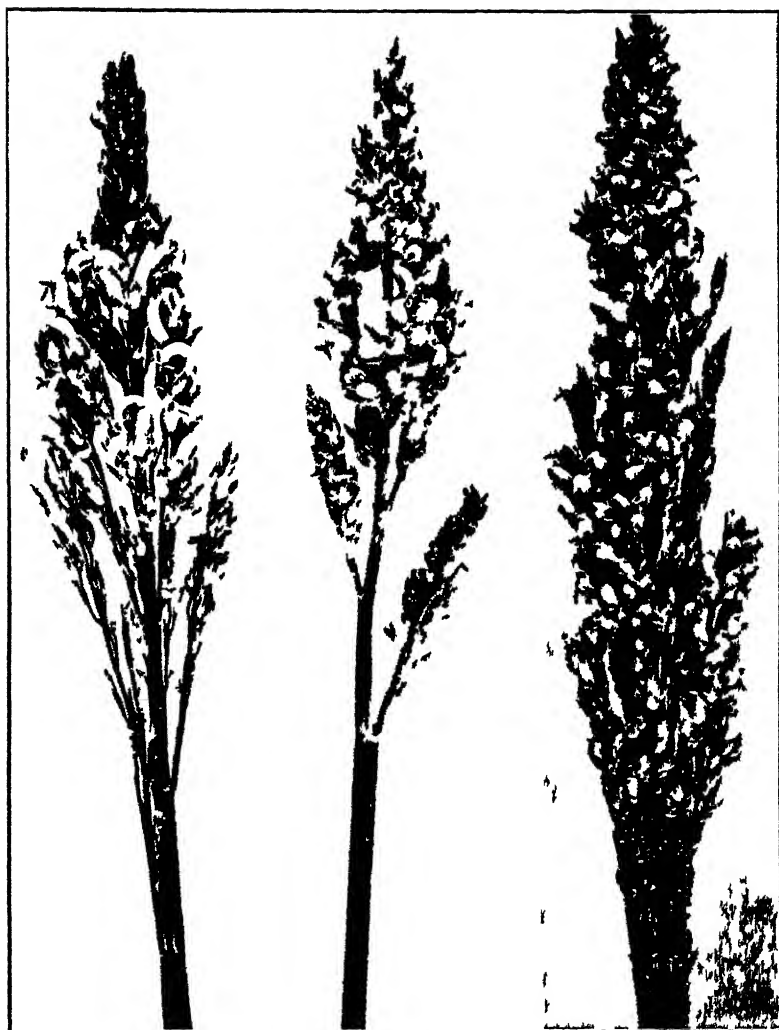
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3

VALLEY KAOLIANG INFECTED BY *SPHACELOTHECA CRUENTA*







1

2

3

SORGHUMS INFECTED BY SPHACELOTHECA CRUENTA





1



2



3



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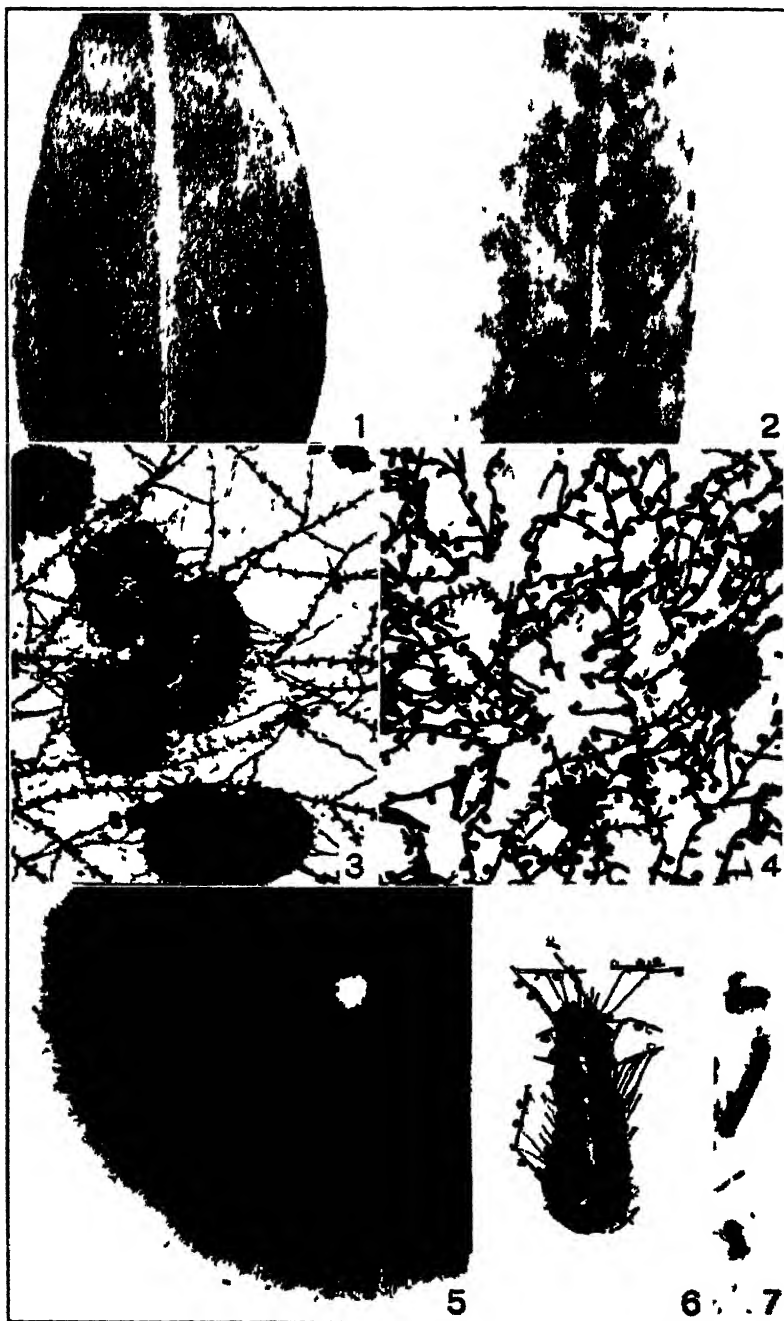
SECONDARY INFECTION OF SORGHUMS BY *SPHACLOTHECA ORIENTA*



about two dozen clusters of the phosphorescent and poisonous species, *Clitocybe illudens*, growing from live-oak roots and stumps. Such was the brilliancy of these clusters that they suggested huge orange flowers blossoming without stalks directly from the earth.

The above brief sketch may give *some* idea of collecting about St. Augustine early in December. The climate here is one of the finest in the world and the whole region very charming.

W. A. MURRILL



HEMISPHERIALES AND PERISPORIALES

# MYCOLOGIA

VOL. XVII JULY-AUGUST, 1925

No. 4

## NEW OR NOTEWORTHY PORTO RICAN PYRENOMYCETES<sup>1</sup>

RAFAEL A. TORO

(WITH PLATES 15 AND 16)

An increasing interest in the study of Porto Rican fungi is indicated by the fact that the Island has been visited in recent years by a considerable number of collectors. Moreover, their collections have been the subject of occasional mycological papers. The majority of these are cited in the bibliographies of Stevenson (14), Chardon (3) and Cook (4), while a list of the different collections is given by Chardon (3). An additional collection was made during the early part of 1923 by Doctor F. J. Seaver of the New York Botanical Garden and Mr. C. E. Chardon, Commissioner of Agriculture and Labor of Porto Rico, and another during the summer of 1924 by Professor H. H. Whetzel of Cornell University, Doctor F. D. Kern of Pennsylvania State College and the writer.

Recently, a number of important papers dealing with Porto Rican fungi have appeared. Spegazzini (11) has published an extensive work based, apparently, on the collections of Stevens; Petrak (8) describes many new species from specimens obtained from the collection of Fink; Miss Ryan (9), having made an exhaustive study of the Microthyriaceae encountered in the herbarium of Stevens, adds many new species to this group, while the writer (21) has published a list of the Pyrenomycetes found in the Seaver-Chardon collection including several forms

<sup>1</sup> Also presented to the Faculty of the Graduate School of Cornell University as a major thesis in partial fulfillment of the requirements for the degree of Master of Science.

[MYCOLOGIA for May-June (17: 89-130) was issued May 1]



not hitherto known from the Island. The present paper is based on material obtained from several different collections. In those cases in which the herbarium is not mentioned it should be understood that the specimens are deposited in the herbarium of Cornell University.

The writer wishes to acknowledge his obligation to Doctor N. L. Britton of the New York Botanical Garden for identification of the hosts of the fungi studied; to Doctor F. J. Seaver of the same institution for his courtesy and coöperation during the writer's three visits there; to Professor R. Thaxter who made available material in the herbarium of Harvard University; to Doctor Mel. T. Cook for specimens of *Meliola* in the herbarium of the Insular Experiment Station, Porto Rico; to Mr. C. E. Chardon for putting at the writer's disposal his entire herbarium; to Doctor F. L. Stevens of the University of Illinois who sent a collection containing twenty-three of his *Meliola* types and some of the Microthyriaceae studied by Miss Ryan; to Doctor C. Spegazzini of La Plata, Argentine, for courteous advice in correspondence; to Professor H. H. Whetzel of the Department of Plant Pathology, Cornell University, for aid and encouragement given during the progress of the work; to Mr. W. R. Fisher of the same Department for the care taken in the preparation of the photographs which illustrate the paper, and to Professor H. M. Fitzpatrick, under whose direction the investigation was carried on, for valuable suggestions and coöperation.

The system of classification proposed by Theissen and Sydow (20) will be followed.

## HEMISPHERIALES

### MICROTHYRIACEAE

#### ASTERINA Lév.

*ASTERINA DIPLOCARPA* Cooke, Grevillea 10: 129. 1882.

*Asterina Sidae* Earle, Bull. New York Bot. Gard. 3: 310. 1905.

*Asterina sidicola* Ryan, Mycologia 16: 181. 1924.

Theissen (18) demonstrated that *A. Sidae* Earle is identical with *A. diplocarpa* Cooke. The writer has examined type material of *A. Sidae* Earle and *A. sidicola* Ryan and has found them to be the same.

## MATERIAL EXAMINED:

On *Sida carpinifolia* L.f. Rick, Fungi Austro-Americani 325 (in herbarium Harvard University); herbarium C. E. Chardon, Earle 366; Porto Rico Fungi, Stevens 410 (in herbarium R. A. Toro); Explorations of Porto Rico, Whetzel, Kern and Toro 2525, 2526, 2528.

On *Abutilon* sp. Porto Rico Fungi, Stevens 5642 (in herbarium R. A. Toro).

On Malvaceae. Porto Rico Fungi, Stevens 5693, 6663a (in herbarium R. A. Toro).

**Asterina Kernii** sp. nov.

Epiphyllous, effuse, forming a thin spreading carbonaceous layer covering the surface of the leaf; mycelium radiating, branches opposite or frequently unilateral, undulate; hyphae fuscous, 3-4  $\mu$  thick, septate, cells 20-25  $\mu$  long; hyphopodia opposite, sessile, rounded or slightly attenuated at the apex, 7-9  $\mu$  long, 5-6  $\mu$  wide; thiriothecia scattered, often confluent, flattened-hemispherical, 132-208  $\mu$  in diameter, composed of radiating hyphae about 3  $\mu$  thick, fimbriate, center opaque, dehiscence stellate; asci broadly elliptical, thick-walled, sessile, 42-56 x 35-46  $\mu$ , 8-spored; spores conglobate, 1-septate, smooth, 21-28 x 14  $\mu$ , hyaline when young, light brown with age, constricted at the septum; each cell subspherical, upper cell slightly broader (Pl. 15, figs. 2-3).

## MATERIAL EXAMINED:

On *Brunellia comocladifolia* H. & B. Explorations of Porto Rico, Whetzel, Kern and Toro 2481 (Type).

ASTERINA CORIACELLA Speg., Bol. Acad. Nac. Ci. Cordoba 11: 560. 1889.

Referred to *Asterina solanicola* B. & C. by Ryan, Mycologia 16: 184. 1924.

The Porto Rican material has been compared with authentic specimens of the South American species and found to be the same.

## MATERIAL EXAMINED:

On *Cestrum* sp. Theissen, Decades Fungorum Brasilensium 50; Rehm, Ascomycetes 1699b (both in herbarium Harvard University).

On *Cestrum la. difolium* Thér. Porto Rico Fungi, *Stevens* 8533 (in herbarium University of Illinois).

On *Cestrum macrophyllum* Vent. Explorations of Porto Rico, *Wetzel, Kern and Toro* 2512.

ASTERINA SOLANICOLA B. & C., Jour. Linn. Soc. 10: 374. 1867.

*Asterina triloba* Earle, Bull. New York Bot. Gard. 3: 310. 1905.

Referred to *Asterina diplocarpa* Cooke by Ryan, Mycologia 16: 186. 1924.

A comparison of the type species of *A. solanicola* B. & C. with *A. triloba* Earle shows them to be the same. Theissen (18) noted the similarity between the two.

#### MATERIAL EXAMINED:

On *Solanum* sp. Wright's Cuban Fungi 738 (in herbarium Harvard University).

On *Croton discolor* W. Porto Rico Fungi, *Heller* 6216 (in herbarium C. E. Chardon); Porto Rico Fungi, *Stevens* 8540 (in herbarium N. Y. Botanical Garden).

#### MORENOELLA Speg.

##### **Morenoella Whetzelii** sp. nov.

Spots epiphyllous, 3–5 mm. in diameter; thiriothecia scattered, elongated, 150–350 x 124–140  $\mu$ , attenuated toward the ends, often curved; dehiscence by a regular longitudinal slit; mycelium radiating from each thiriothecium, distinct, more or less interwoven, fuscous, septate, branched, anastomosing, 3–4  $\mu$  thick; hyphopodia alternate, 3–4-lobed, sessile, 9–10 x 12  $\mu$ ; asci broadly ovate, sessile, thick-walled, rounded at the apex, tunicated at the base, 39–45 x 27–31  $\mu$ , 8-spored; spores inordinate, unequally 1-septate, 21–24 x 7–9  $\mu$ , hyaline when young, fuscous with age, slightly constricted at the septum; lower cell broader, spherical; upper ellipsoid (Pl. 16, figs. 6, 14, 19).

#### MATERIAL EXAMINED:

On *Securidaca volubilis* L. Explorations of Porto Rico, *Whetzel, Kern and Toro* 2483 (Type).

## HEMISPHERIACEAE

## MICROPILTIS Mont.

MICROPILTIS ALBO-MARGINATA Speg., Bol. Acad. Nac. C.  
Cordoba 11: 572. 1889.

Although no material has been available for comparison the Porto Rican specimen agrees well with the original description. The species has not been reported before from the Island (Pl. 16, figs. 10-11).

## MATERIAL EXAMINED:

On unknown host. Explorations of Porto Rico. *Seuter and Chardon 1712*.

*Scolecopeltis* Speg. char. emend.

Thiriothecia dimidiate, shield-shaped, superficial; asci 2-8-spored; spores filiform, several septate; paraphysoid tissue present or absent.

The genus *Scolecopeltis* was founded by Spegazzini (10) and was originally placed by him in the Microthyriaceae. In a revision of this family v. Höhnelt (24) excludes the genus and places it among the shield-shaped Sphaeriaceae, basing the change on the absence of the inverse-radiate character of the perithecium. He (22) established the genus *Scolecopeltopsis* v. Höhnelt as a member of the Hypocreaceae with the characters of *Scolecopeltis* Speg. Theissen and Sydow (20) disregard the genus and cite the name as a synonym of *Scolecopeltis* Speg.

Theissen (16) considering the shield-shaped character of the perithecium as of essential taxonomic significance grouped all the forms with this structure in the single order Hemisphaeriales. He recognized three families: Microthyriaceae, with inverse-radiate perithecial membranes; Trichopeltaceae, with membranes formed through thickenings of the vegetative thallus, and Hemisphaeriaceae, with shield-shaped membranes lacking the inverse-radiate character. He transferred the genus *Scolecopeltis* Speg. to the last family and placed it next to *Micropeltella* Sydow.

The type species of the genus, as well as the majority of the other described species, lacks paraphyses. However, Sydow (15) v. Höhnelt (23) and others have included in the genus species

with paraphyses. The writer also has encountered species which are paraphysate. Theissen 17 points out that the ends of the hyphal branches in this group of fungi sometimes pass between the asci giving them an appearance of having paraphyses. In this connection he says: "jedenfalls kann man dann nicht zwischen Arten mit untypischen Paraphysen und solchen ohne Paraphysen wieder eine generische Grenze ziehen, da diese Grenzen unfassbar sind." Arnaud (1) also found that paraphyses in this group are not homologous with the paraphyses of the Sphaeriales and Discomycetes but that they are instead sterile hyphae arising from the stroma. For this reason he named them "tissu-paraphysoide." Since their presence or absence does not furnish a sufficiently important character to justify the establishment of a new genus, the above emended description is proposed.

#### KEY TO PORTO RICAN SPECIES

Paraphysoid tissue absent.

Thiriothecia less than 500  $\mu$  in diameter.

Spores not exceeding 60  $\mu$  in length . . . . . *S. pachyasca*.

Spores often exceeding 60  $\mu$  in length . . . . . *S. longispora*.

Thiriothecia often exceeding 500  $\mu$  in diameter.

Spores 100-120  $\mu$  long . . . . . *S. portoricensis*.

Spores 140-150  $\mu$  long . . . . . *S. micropeltiformis*.

Paraphysoid tissue present.

Thiriothecia less than 500  $\mu$  in diameter . . . . . *S. Cestri*.

Thiriothecia often exceeding 500  $\mu$  in diameter.

Spores less than 120  $\mu$  long.

Thiriothecia 400-500  $\mu$  in diameter . . . . . *S. Ionopsidis*.

Thiriothecia 500-800  $\mu$  in diameter . . . . . *S. Ingae*.

Spores reaching 135  $\mu$  in length . . . . . *S. Chardonii*.

*SCOLECOPELTIS PACHYASCA* Speg., Bol. Acad. Nac. Ci. Cordoba  
26: 353. 1923.

This fungus is reported on leaves of *Coccolobis laurifolia* Jacq. No material has been available for study.

*Scolecopeltis longispora* (Earle) comb. nov.

*Micropeltis longispora* Earle, Bull. New York Bot. Gard. 3: 311.  
1905.

The spores here are about the same size as those of *S. pachyasca* as figured by Spegazzini (11) but differ in that they do not fall apart at the septa at maturity. The presence of a halo around the thiriothecium seen here is absent in *S. pachyasca*.

## MATERIAL EXAMINED:

On *Coffea arabica* L. Porto Rico Fungi. *Heller 6349* (in herbarium N. Y. Botanical Garden).

*Scolecopeltis portoricensis* Speg., Bol. Acad. Nac. Ci. Cordoba 26: 352. 1923.

This fungus is reported from leaves of *Canella Winterana* 'L. Gaert. No material has been seen.

***Scolecopeltis micropeltiformis* sp. nov.**

Thiriothecia epiphyllous, evenly distributed over the surface of the leaf, numerous, not confluent, blue-black, 500–550  $\mu$  in diameter; ostiolum circular, 20–25  $\mu$  in diameter; asci ellipsoid, at the apex rounded and thick-walled, 150–165  $\times$  38–42  $\mu$ , 8-spored, short pedicellate, pedicel about 6  $\mu$  long; spores filiform, thick-walled, parallel or inordinate, slightly shorter than the ascus, 140–150  $\times$  5–7  $\mu$ , 13–17 septate, often separating into two equal segments, hyaline (Pl. 15, fig. 5).

## MATERIAL EXAMINED:

On *Casearia sylvestris* Sw. Explorations of Porto Rico, *Whetzel, Kern and Toro 2513* (Type).

***Scolecopeltis Cestri* sp. nov.**

Thiriothecia hypophyllous, scattered, black at center, paler toward the edges, 300–425  $\mu$  in diameter, circumscribed by an inconspicuous hyaline zone; ostiolum circular, 30–40  $\mu$  in diameter; asci cylindric, 117–122  $\times$  31  $\mu$ , 5–6-spored, thick-walled at the apex, cuneiform at the base and terminating in a short pedicel 4–6  $\mu$  long; spores parallel, filiform, thick-walled, 110–115  $\times$  4–6  $\mu$ , 11–18 septate, hyaline, frequently separating into unequal segments; cells subequal in size with the end cells pointed; paraphysoid tissue present.

Associated with *Aulographum Cestri* Ryan.

## MATERIAL EXAMINED:

On *Cestrum* sp. Porto Rico Fungi, *Stevens 7576* (Type) (in herbarium University of Illinois).

***Scolecopeltis Ionopsidis* sp. nov.**

Thiriothecia amphigenous, abundant, scattered, black at center, paler toward the edges, 420–504  $\mu$  in diameter, circum-

scribed by a hyaline zone  $15-30\ \mu$  wide; ostiolum round to slightly angular,  $30-40\ \mu$  in diameter; asci sub-cylindric, often curved,  $90-118 \times 20-25\ \mu$ , 6-8-spored, at the apex rounded and thick-walled, at the base cuneiform and terminating in a small pedicel  $5\ \mu$  long; spores parallel or inordinate, filiform, hyaline, thick-walled,  $80-115 \times 3-5\ \mu$ , 13-15 septate, easily separating into unequal segments  $6-20\ \mu$  long; paraphysoid tissue present.

MATERIAL EXAMINED:

On *Ionopsis utricularioides* (Sw.) Lindl. Explorations of Porto Rico, Whetsel, Kern and Toro 2511 (Type).

*Scolecopeltis Ingae* sp. nov.

Thiriothecia hypophyllous, scattered, light green at the center, paler toward the edges,  $500-800\ \mu$  in diameter; composed of a dense weft of fungous hyphae  $1\ \mu$  thick, circumscribed by a hyaline zone  $30-60\ \mu$  wide; ostiolum circular,  $50-60\ \mu$  in diameter; asci ellipsoid,  $115-140 \times 22-27\ \mu$ , 4-8-spored, round and thick-walled at the apex, thinner and sessile at the base; spores filiform, hyaline, nearly straight, thick-walled,  $85-118 \times 7-9\ \mu$ , 14-22 septate; end cells pointed; paraphysoid tissue present (Pl. 16, fig. 9).

MATERIAL EXAMINED:

On *Inga Inga* (L.) Britton. Explorations of Porto Rico, Whetsel, Kern and Toro 2518 (Type).

On *Inga laurina* (Sw.) Willd. Explorations of Porto Rico, Whetsel, Kern and Toro 2514, 2523.

*Scolecopeltis Chardonii* sp. nov.

Thiriothecia amphigenous, mostly hypophyllous, scattered, opaque, blue-black at the center, paler toward the edges, composed of a dense weft of fungous hyphae  $1-1.5\ \mu$  thick,  $500-625\ \mu$  in diameter; ostiolum round,  $32-40\ \mu$  in diameter; asci ellipsoid,  $108-138 \times 19-35\ \mu$ , 2-6-spored, the tip obtuse and thick-walled, the base sessile to short pedicellate; spores hyaline, curved, rarely straight, thick-walled,  $72-135 \times 6.5-7\ \mu$ , tapering toward the ends, 11-20 septate, easily separating into unequal segments; paraphysoid tissue present (Pl. 15, fig. 1 and Pl. 16, fig. 8).

MATERIAL EXAMINED:

On *Maytenus elongata* (Urb.) Britton. Herbarium R. A. Toro 59 (Type).

## CLYPEOLUM Speg.

CLYPEOLUM SCUTELLIFORME Rehm, Hedwigia 37: 322. 1898.

Although no material has been available for comparison the Porto Rican specimen agrees well with the original description. The species has not been hitherto reported from the Island.

*Micropeltis albo-marginata* Speg. also present (Pl. 16, fig. 11).

## MATERIAL EXAMINED:

On unknown host. Explorations of Porto Rico, *Seaver and Chardon 1712*.

## PERISPORIALES

## PERISPORIACEAE

## IRENE Theiss. &amp; Syd.

**Irene glabra** (Berk. & Curt.) comb. nov.

*Meliola glabra* Berk. & Curt., Jour. Linn. Soc. 10: 392. 1867.

The genus *Irene* was established by Theissen and Sydow (15) for species of *Meliola* devoid of setae. The genus is well represented in Porto Rico.

## MATERIAL EXAMINED:

On *Piper aduncum* L. Porto Rico Fungi, *Heller 6204* (in herbarium C. E. Chardon).

**Irene sepulta** (Pat.) comb. nov.

*Meliola sepulta* Pat.: Stevens, Illinois Biol. Monog. 2: 14. 1916.

## MATERIAL EXAMINED:

On *Avicennia nitida* Jacq. Herbarium Insular Experiment Station 333.

**Irene irregularis** (Stev.) comb. nov.

*Meliola irregularis* Stev., Illinois Biol. Monog. 2: 15. 1916.

## MATERIAL EXAMINED:

On *Hygrophila brasiliensis* (Spreng.) Lindl. Porto Rico Fungi, *Stevens 9283* (in herbarium N. Y. Botanical Garden).

**Irene hyptidicola** (Stev.) comb. nov.

*Meliola hyptidicola* Stev., Illinois Biol. Monog. 2: 16. 1916.



## MATERIAL EXAMINED:

On *Hyptis lantanifolia* Poit. Porto Rico Fungi, *Stevens* 8130 (in herbarium C. E. Chardon).

On *Hyptis capitata* Jacq. Cornell University, Explorations of Porto Rico, *Chardon* 862; Explorations of Porto Rico, *Whetzel, Kern and Toro* 2517.

On *Hyptis atrorubens* Poit. Explorations of Porto Rico, *Whetzel, Kern and Toro* 2520.

***Irene cyclopoda*** (Stev.) comb. nov. (Pl. 15, fig. 4).

*Meliola cyclopoda* Stev., Illinois Biol. Monog. 2: 16. 1916.

## MATERIAL EXAMINED:

On *Pseudelephantopus spicatus* (Juss.) Rohr. Porto Rico Fungi, *Stevens* 7733 (in herbarium N. Y. Botanical Garden); 7871 (in herbarium University of Illinois).

***Irene aibonitensis*** (Stev.) comb. nov.

*Meliola aibonitensis* Stev., Illinois Biol. Monog. 2: 16. 1916.

## MATERIAL EXAMINED:

On *Daphnopsis caribaea* Griseb. Porto Rico Fungi, *Stevens* 8140 (in herbarium C. E. Chardon); 8479 (in herbarium N. Y. Botanical Garden).

***Irene Perseae*** (Stev.) comb. nov.

*Meliola Perseae* Stev., Illinois Biol. Monog. 2: 17. 1916.

Spegazzini (12) refers to *Meliola Perseae* forma *setulifera* a specimen (Ravenel, Fungi Am. Exsicc. 82) which he examined from material collected in Florida. He makes the statement that certain species of *Meliola* may sometimes have setae and sometimes not, depending upon whether the fungus is hypophyllous or epiphyllous. This fact, however, can hardly be held to invalidate the genus *Irene*.

## MATERIAL EXAMINED:

On *Persea Persea* (L.) Cockerell. Porto Rico Fungi, *Stevens* 8212 (in herbarium N. Y. Botanical Garden).

**Irene Lagunculariae** (Earle) comb. nov.

*Meliola Lagunculariae* Earle, Muhlenbergia 1: 11. 1901.

## MATERIAL EXAMINED:

On *Laguncularia racemosa* (L.) Gaert. Porto Rico Fungi, *Heller 4361a* (in herbarium N. Y. Botanical Garden); Porto Rico Fungi, *Stevens 1364* (in herbarium C. E. Chardon).

**Irene longipoda** (Gaill.) comb. nov.

*Meliola longipoda* Gaill., Bull. Soc. Myc. Fr. 8: 178. 1892.

## MATERIAL EXAMINED:

On *Cordia* sp. Porto Rico Fungi, *Stevens 7472* (in herbarium C. E. Chardon); Cornell University, Explorations of Porto Rico, *Whetzel and Olive 610*.

On *Cordia nitida* Vahl. Porto Rico Fungi, *Stevens 9329* (in herbarium University of Illinois).

On *Varronia corymbosa* (L.) Desv. Explorations of Porto Rico, *Whetzel, Kern and Toro 2516*.

**Irene portoricensis** sp. nov.

Epiphyllous, forming circular spots 0.5–1.5 mm. in diameter, composed of a closely adhering mat of mycelial threads; mycelium septate, tortuous, dark brown, hyphae 150–250  $\mu$  long, 6–7  $\mu$  wide; capitate hyphopodia numerous, alternate or unilateral, sessile, globose, 2–6 per cell, 12–14  $\mu$  in diameter; mucronate hyphopodia opposite, bottle shaped, light brown, 19  $\mu$  long; perithecia black, globose-applanate, 2–8 in each spot, arranged in a circle, 77–150  $\mu$  in diameter, rough; asci evanescent; spores cylindrical-ellipsoidal, 4-celled, constricted at septa, 33–35  $\times$  14–16  $\mu$ , brown; end cells sub-equal, obtuse, middle cells equal (Pl. 16, figs. 15–16).

## MATERIAL EXAMINED:

On *Acnistus arborescens* (L.) Schlet. Explorations of Porto Rico, *Whetzel, Kern and Toro 2527 (Type)*; Cornell University, Explorations of Porto Rico, *Chardon 866*.

**Irene Melastomacearum** (Speg.) comb. nov.

*Meliola Melastomacearum* Speg., Bol. Acad. Nac. Ci. Cordoba 11: 495. 1889.

## MATERIAL EXAMINED:

On *Clidemia hirta* (L.) D. Don. Porto Rico Fungi, *Stevens* 9479 (in herbarium Insular Experiment Station); Cornell University, Explorations of Porto Rico, *Chardon* 871; herbarium R. A. Toro 30.

On *Miconia prasina* (Sw.) P. DC. Explorations of Porto Rico, *Whetzel, Kern and Toro* 2522.

On *Miconia laevigata* (L.) DC. Explorations of Porto Rico, *Whetzel, Kern and Toro* 2524.

***Irene glabroides* (Stev.) comb. nov.**

*Meliola glabroides* Stev., Illinois Biol. Monog. 2: 18. 1916.

## MATERIAL EXAMINED:

On *Nectandra patens* (Sw.) Griseb. Porto Rico Fungi, *Stevens* 4852 (in herbarium N. Y. Botanical Garden).

On *Sauragesia erecta* L. Cornell University, Explorations of Porto Rico, *Whetzel and Olive* 616; Explorations of Porto Rico, *Whetzel, Kern and Toro* 2521.

On *Valerianodes cayennensis* (L. Cl. Rich.) Vahl. Explorations of Porto Rico, *Whetzel, Kern and Toro* 2515.

**IRENE TRILOBA** (Wint.) Theiss. & Syd., Ann. Myc. 15: 461. 1917.

*Meliola triloba* Wint., Hedwigia 25: 95. 1886.

## MATERIAL EXAMINED:

On *Pilea paretaria* (L.) Bl. Porto Rico Fungi, *Stevens* 7232 (in herbarium Insular Experiment Station).

## APPENDICULELLA v. Höhnelt

**APPENDICULELLA CALOSTROMA** (Desm.) v. Höhn., Sitz. Akad. Wiss. Wien 128: 22. 1919.

*Sphaeria calostroma* Desm., Bull. Soc. Myc. Fr. 4: 1011. 1857.

*Chaetosphaeria calostroma* (Desm.) Sacc., Syll. Fung. 2: 95. 1883.

*Meliola manca* Ell. & Mart., Am. Nat. 17: 1284. 1883.

*Meliola sanguinea* Ell. & Everh., Journ. Myc. 2: 42. 1886.

*Meliola Puiggarii* Speg., Bol. Acad. Nac. Ci. Cordoba 11: 492. 1889.

*Meliola rubicola* P. Henn., Hedwigia 43: 140. 1904.

*Meliola calostroma* (Desm.) v. Höhn., Ann. Myc. 15: 363. 1917.

*Irene manca* (Ell. & Mart.) Theiss. & Syd., Ann. Myc. 15: 461. 1917.

*Irene calostroma* (Desm.) v. Höhn., Ann. Myc. 16: 213. 1918.

*Irene Puiggarii* (Speg.) Doidge, Trans. Roy. Soc. South Africa 9: 122. 1919.

The genus *Appendiculella* was founded by v. Höhnelt (27) for species formerly assigned to the genus *Meliola* Fr. which lack setae and possess vermiform perithecial appendages.

There has been great difference of opinion regarding the species of *Meliola* occurring on *Rubus* and *Myrica*. Stevens (13) and Doidge (5) claim that the specimens which they refer to *Meliola manca* Ell. & Mart. do not have the vermiform perithecial appendages which Gaillard (7) figures for this species. Beeli (2) places *M. manca* Ell. & Mart. and *M. rubicola* P. Henn. in the same section and with identical formulae, but refers *M. Puiggarii* Speg. to a different section. Ellis and Everhart (6) consider *M. sanguinea* Ell. & Everh. a synonym of *M. manca* Ell. & Mart. while Gaillard (7) adds *M. Puiggarii* Speg. to the synonymy. v. Höhnelt (25) shows that *Sphaeria calostroma* Desm. is a *Meliola*. He (26) establishes the identity of this fungus with *M. manca* Ell. & Mart., *M. sanguinea* Ell. & Everh., *M. Puiggarii* Speg. and *M. rubicola* P. Henn. all of which he puts under *Irene calostroma* (Desm.) v. Höhnelt.

All the specimens examined by the writer show the vermiform perithecial appendages distinctly. The ones on *Myrica cerifera* L. may however be confusing. Here though the appendages are sometimes very apparent, at others they are so poorly developed that they may be either overlooked or mistaken for the conical projections of the lower cells of the perithecium.

#### MATERIAL EXAMINED:

On *Rubus* sp. Desmazières, Pl. Crypt. Fr. 8: 368; Rehm, Ascomycetes 2132 (both in herbarium Harvard University); Flora Ludoviciana 74 (in herbarium N. Y. Botanical Garden); Porto Rico Fungi, Stevens 8650 (in herbarium C. E. Chardon); 8892 (in herbarium Insular Experiment Station).

On *Myrica cerifera* L. Ellis N. A. F. 1292 (1 specimen in herbarium Philadelphia Academy of Sciences, 2 specimens in herbarium N. Y. Botanical Garden); Porto Rico Fungi, *Stevens* 5289 (in herbarium C. E. Chardon).

**Appendiculella compositarum** (Earle) comb. nov. (Pl. 16, fig. 13).

*Meliola compositarum* Earle, Bull. New York Bot. Gard. 3: 306. 1905.

MATERIAL EXAMINED:

On *Mikania cordifolia* (L.f.) Willd. Porto Rico Fungi, *Heller* 6385 (in herbarium C. E. Chardon).

On *Eupatorium odoratum* L. Porto Rico Fungi, *Fink* 182, 196 (in herbarium C. E. Chardon); Porto Rico Fungi, *Stevens* 7977 (in herbarium C. E. Chardon); Explorations of Porto Rico, *Whetzel, Kern and Toro* 2519.

**Appendiculella Calophylli** (Stev.) comb. nov.

*Meliola Calophylli* Stev., Illinois Biol. Monog. 2: 22. 1916.

MATERIAL EXAMINED:

On *Calophyllum antillanum* Britton (*Calophyllum Calaba* Jacq. not L.). Porto Rico Fungi, *Stevens* 7059 (in herbarium Insular Experiment Station).

**Appendiculella tuberculata** (Stev.) comb. nov.

*Meliola tuberculata* Stev., Illinois Biol. Monog. 2: 22. 1916.

MATERIAL EXAMINED:

On unknown host. Porto Rico Fungi, *Stevens* 7742 (in herbarium N. Y. Botanical Garden).

**Appendiculella arecibensis** (Stev.) comb. nov. (Pl. 15, fig. 7).

*Meliola arecibensis* Stev., Illinois Biol. Monog. 2: 23. 1916.

MATERIAL EXAMINED:

On *Acalypha bisetosa* Bert. Porto Rico Fungi, *Stevens* 365a (in herbarium University of Illinois); 6547 (in herbarium N. Y. Botanical Garden).

## CAPNODIACEAE

PHAEOSACCARDINULA P. Henn.

**Phaeosaccardinula Seaveriana** sp. nov.

Subiculum amphigenous, effuse, covering the entire upper surface of the leaf, cinereous-olivaceous; mycelium sub-hyaline, septate, moniliform, deeply constricted at the septa; cells unequal,  $7-23 \times 6-8 \mu$ ; perithecia scattered, superficial, globose-hemispherical, black, glabrous,  $168-200 \mu$  in diameter; asci fasciculate, broadly-clavate, sessile, thin-walled,  $60-70 \times 22-30 \mu$ , mostly 4-spored, never 8-spored; spores inordinate, ellipsoid-elongate, muriform, with 4-7 transverse and 2-4 longitudinal septa, thin-walled,  $39-45 \times 16-18 \mu$ , hyaline (Pl. 16, fig. 12).

## MATERIAL EXAMINED:

On *Erythrina glauca* Willd. Explorations of Porto Rico, *Seaver and Chardon 1316* (Type).

## POSITION DOUBTFUL

## TRICHOthyRIACEAE

## TRICHOthyRIUM Speg.

TRICHOthyRIUM COLLAPSUM (Earle) Theiss., Ann. Myc. 15: 488. 1917.

*Pseudomeliola collapsa* Earle, Bull. New York Bot. Gard. 3: 309. 1905.

## MATERIAL EXAMINED:

On *Meliola* sp. on *Potomorphe peltata* (L.) Miq. Porto Rico Fungi, *Heller 6400* (in herbarium N. Y. Botanical Garden).

TRICHOthyRIUM DUBIOSUM (Bom. & Br.) Theiss., Beih. Bot. Cent. 32: 8. 1914.

*Asterina dubiosa* Bom. & Br., Bul. Soc. Bot. Belgium 32: 157. 1896.

This agrees well with the description given by Theissen (19). The species has not been reported before from the Island (Pl. 16, fig. 17-18).

## MATERIAL EXAMINED:

On *Irene Melastomacearum* (Speg.) Toro on *Clidemia hirta*

(L.) D. Don. Porto Rico Fungi, *Stevens 9479* (in herbarium Insular Experiment Station).

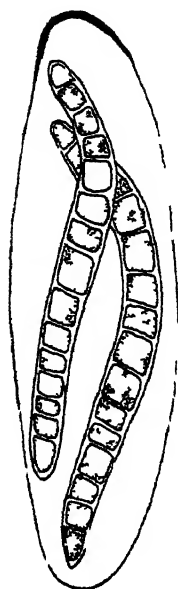
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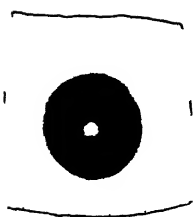
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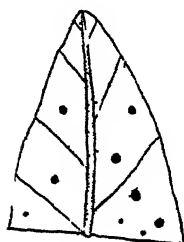
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HEMISPHERIALES AND PERISPORIALES

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## EXPLANATION OF PLATES

## PLATE 15

- Fig. 1. *Scolecopeltis Chardonii*. Thiriothecia on leaf of *Maytenus elongata*.  $\times 1$ .
- Fig. 2. *Asterina Kernii*. Leaf of *Brunellia comocladifolia* showing habit of fungus.  $\times 1.5$ .
- Fig. 3. *Asterina Kernii*. Group of thiriothecia. Notice the stellate character of dehiscence and the small, opposite hyphopodia.  $\times 90$ .
- Fig. 4. *Irene cyclopodu*. Perithecium and mycelium. Setae lacking.  $\times 95$ .
- Fig. 5. *Scolecopeltis micropeltiformis*. Section of a thiriothecium showing its characteristic structure.  $\times 95$ .
- Fig. 6. *Morenoella Whetselii*. A thiriothecium with radiating mycelial threads.  $\times 90$ .
- Fig. 7. *Appendiculella arecibensis*. A single vermiform perithecial appendage.  $\times 90$ .

## PLATE 16

- Fig. 8. *Scolecopeltis Chardonii*. Ascus and two spores.  $\times 450$ .
- Fig. 9. *Scolecopeltis Ingae*. Diagrammatic sketch of a piece of leaf of *Inga Inga* showing a thiriothecium surrounded by a hyaline zone.
- Fig. 10. *Micropeltis albo-marginata*. Ascus and eight spores.  $\times 450$ .
- Fig. 11. *Clypeolum scutelliforme* and *Micropeltis albo-marginata*. Tip of a leaf of an unknown host showing six thiriothecia of the former and near the lower margin three of the latter.  $\times 1$ .
- Fig. 12. *Phaeosuccardinula Severiana*. Two spores.  $\times 450$ .
- Fig. 13. *Appendiculella compositarum*. A perithecial appendage.  $\times 450$ .
- Fig. 14. *Morenoella Whetselii*. Two spores.  $\times 450$ .
- Fig. 15. *Irene portoricensis*. Mycelial thread with mucronate hyphopodia.  $\times 450$ .
- Fig. 16. *Irene portoricensis*. A spore.  $\times 450$ .
- Fig. 17. *Trichothyrium dubiosum*. Two spores.  $\times 450$ .
- Fig. 18. *Trichothyrium dubiosum* showing habit of fungus on mycelium of *Irene Melastomacearum*.  $\times 450$ .
- Fig. 19. *Morenoella Whetselii*. An ascus and eight immature spores.  $\times 450$ .

# THE LIFE CYCLE OF THE RUST ON FLY POISON, *CHROSPERMA MUSCAETOXICUM*

C. R. ORTON AND FREEMAN WEISS<sup>1</sup>

(WITH PLATE 17 AND 1 TEXT FIGURE)

In 1920 Mr. N. R. Hunt collected a rust on "fly poison," *Chrosperma* (*Amianthium*) *muscaetoxicum* (Walt.) Kuntze (text fig. 1), at Upper Lehigh, near Freeland, Pennsylvania. In looking up the literature it was found that this rust, previously collected in Pennsylvania, had been referred by Holway (1905) and Arthur (1920) to *Puccinia atropuncta*, described by Peck and Clinton (1879) on *Veratrum Woodii* from material collected at Allentown, Missouri, by G. W. Letterman. The urediniospores and teliospores of the rusts on the two hosts appear morphologically alike. The urediniospores are especially characterized by possessing two super-equatorial pores.

Holway also includes with *Puccinia atropuncta*, *Puccinia Zygadeni* Trelease on *Zygadenus elegans* and *Puccinia Melanthii* Bubák on *Veratrum* (*Melanthium*) *parviflorum*. Arthur (1920) on the basis of urediniospore characters also places *Uredo Schoenocauli* Ellis & Ev. on *Schoenocaulon dubium* as a synonym of *P. atropuncta*. Both authors consider this an autoecious long-cycle rust, but Holway states that "the only specimen of aecidium seen was collected at Armstrong, Iowa, on *Zygadenus elegans* by R. I. Cratty."

Following the collection by Hunt a survey of the region was made where the rust occurred rather commonly with the hope that some clue to the life-cycle might be found. In no case was there any indication of any other stages than uredinia and telia.

In the spring of 1921 another search was made for aecia on *Chrosperma* but without success. There was found, however, an aecidium on *Nabalus trifoliolatus*, which was closely associated

<sup>1</sup> Joint contribution from the Department of Botany, Pennsylvania State College No. 51, and the Bureau of Plant Industry, U. S. Department of Agriculture.

with the old dead leaves of *Chrosperma* which bore the telia of the *Puccinia*. The field evidence secured by Mr. Hunt and the writers indicated that the rust was probably heteroecious and steps were taken immediately to prove by means of cultures whether this was the case. The aeciospores from *Nabalus trifoliolatus* were sown in the field on *Chrosperma* growing about two miles removed from any known plants infected with the rust. No infection resulted from these tests.



FIG. 1. Photograph of raceme and leaves of *Chrosperma muscaetoxicum*, the latter bearing uredinia and telia of *Puccinia atropuncta*. Note the circular shape of the sori and the chlorotic zone surrounding them. Photograph by W. A. Kuntz, State College, Pa., Nov. 1, 1924.

Plants of *Nabalus* and *Chrosperma* were transported to the greenhouses of the Department of Agriculture in Washington, D. C., but both species failed to thrive in any but a peat soil, and they were not successfully transplanted until 1923. In the spring of 1924 very successful infections were secured at Washington on *Nabalus* by sowing teliospores from *Chrosperma* collected near Freeland in April, 1924.

Germinating teliospores were sown on *Nabalus trifoliolatus* Cass. April 15, 1924, following which pycnia appeared April 28, and aecia May 1 (Pl. 17, fig. 1). Another sowing was made April 28, 1924, with pycnia appearing May 7 followed by aecia May 9. Likewise infections followed by aecial development were secured on *Nabalus serpentarius* (Pursh) Hook. (inoculation May 8, mature aecia May 29—both on potted plants in the greenhouse and on native plants out-of-doors) but this host does not appear to be quite so congenial as the former since the development was much less luxuriant. On *Lactuca canadensis* growing outdoors only obscure purplish spots developed, but sowings on this host were made later (May 29) when the conditions were less favorable for infection. However, aecial infections on *Nabalus trifoliolatus* were secured as late as June 14 from inoculations made on May 29, pycnia appearing on June 10.

Uredinia and telia subsequently were produced on *Chrosperma*, following inoculation with aeciospores from *Nabalus trifoliolatus* (inoculation May 8, uredinia May 29), but failed to develop from inoculation with aeciospores from *N. serpentarius*.

In each instance sowings of spores were made on the original host as well as the suspected alternate host to detect any evidence of an autoecious condition, but only infection of the alternate host was successful.

This seems satisfactory proof that the rust on *Chrosperma muscaetoxicum* is heteroecious, bearing its gametophytic stage (O & I) on *Nabalus* spp. Whether the rust will infect the common *N. albus* has not been tested.

With this discovery it became necessary to determine in what way the aecia of the fly-poison rust differ from the aecia of *Puccinia hieraciata* (Schw.) H. S. Jackson (*Puccinia Opizii* Arth.), a *Carex* rust with aecia on various genera of the Cichoriaceae including *Agoseris*, *Hieracium*, and *Lactuca*. Studies were made of material in the Arthur Herbarium during June, 1924, and it was found that the authentic material of *P. hieraciata* (based on cultures) possesses aeciospores which are somewhat larger than those of the *Chrosperma* rust. The former measure 16–20 x 18–24  $\mu$  with walls about 1  $\mu$  thick. The latter measure 13–18 x 16–18  $\mu$  with walls 1–1.5  $\mu$  thick. The aecia are cupulate,

arranged in rather dense, irregular groups well represented by Plate 17, fig. 2.

The next problem was to determine the status of the aecia collected at Armstrong, Iowa, by Mr. Cratty. If these belong with *Puccinia Zygaeni*, as cited by Holway and Arthur, it is obvious that this rust is distinct from the heteroecious rust on *Chrosperma*, even though the uredinial and telial stages appear morphologically identical. Only one specimen of aecia, which has been referred to *Puccinia atropuncta*, is in the Arthur Herbarium, and a part of this collection is the one seen by Holway and already referred to. It was collected in the same region where the telia of *Puccinia Zygaeni* were collected and this fact apparently was the chief one for supposing that the two stages belonged to the same rust. Upon examining the aeciospores of the Cratty collection it was found that they measured  $16-24 \times 19-28 \mu$  and had walls about  $1.5 \mu$  thick. They correspond in every way with the aecia of *Uromyces Zygaeni* Peck, which is the common *Zygaenus* rust throughout the Rocky Mountains extending to the plains in Kansas. Although this rust was not known farther east than eastern Kansas, there is no reason why it should not occur in northwestern Iowa where Armstrong is located.

Further cultures must establish the exact relationship of aecia occurring on various species of *Nabalus* and related hosts, since the aecia of the two rusts *P. hieraciata* and *P. atropuncta* possess no very remarkable dissimilarities, while striking similarities are shown in both urediniospores and teliospores. The pores in the urediniospores of both rusts number two and are super-equatorial in position. The teliospores are moreover nearly identical. Apparently these two rusts indicate correlation of a sort different from the usual type described by Dietel (1897, 1918), Fischer (1898), Travelbee (1914) and others in which a short-cycle rust is correlated with a long-cycle heteroecious rust, the former appearing on the aecial host of the latter. The classical example of Dietel is *Puccinia Mesneriana* Thüm. on *Rhamnus*, correlated with *Puccinia Rhamni* (Pers.) Wettst. (*P. coronata* Corda) which has its aecial stage on *Rhamnus* spp. Both have coronate teliospores. A different sort of correlation

has been described by Orton (1912) in which both autoecious and heteroecious species of *Uromyces* are identical with species of *Puccinia* on the same or closely related hosts, differing only in the number of teliospore cells.

The correlation indicated in this paper appears unique but undoubtedly parallel cases occur. Here we have two heteroecious species *Puccinia utropuncta* and *P. hieraciata* (*Dicaeoma hieraciatum*) the former with uredinia and telia on Melanthaceae and the latter with its sporophytic stage on Cyperaceae. Both have their gametophytic stages on Cichoriaceae and very possibly both rusts may have aecia which are scarcely distinguishable on *Nabalus*.

Further inoculation experiments since the submission of this manuscript have resulted as follows:

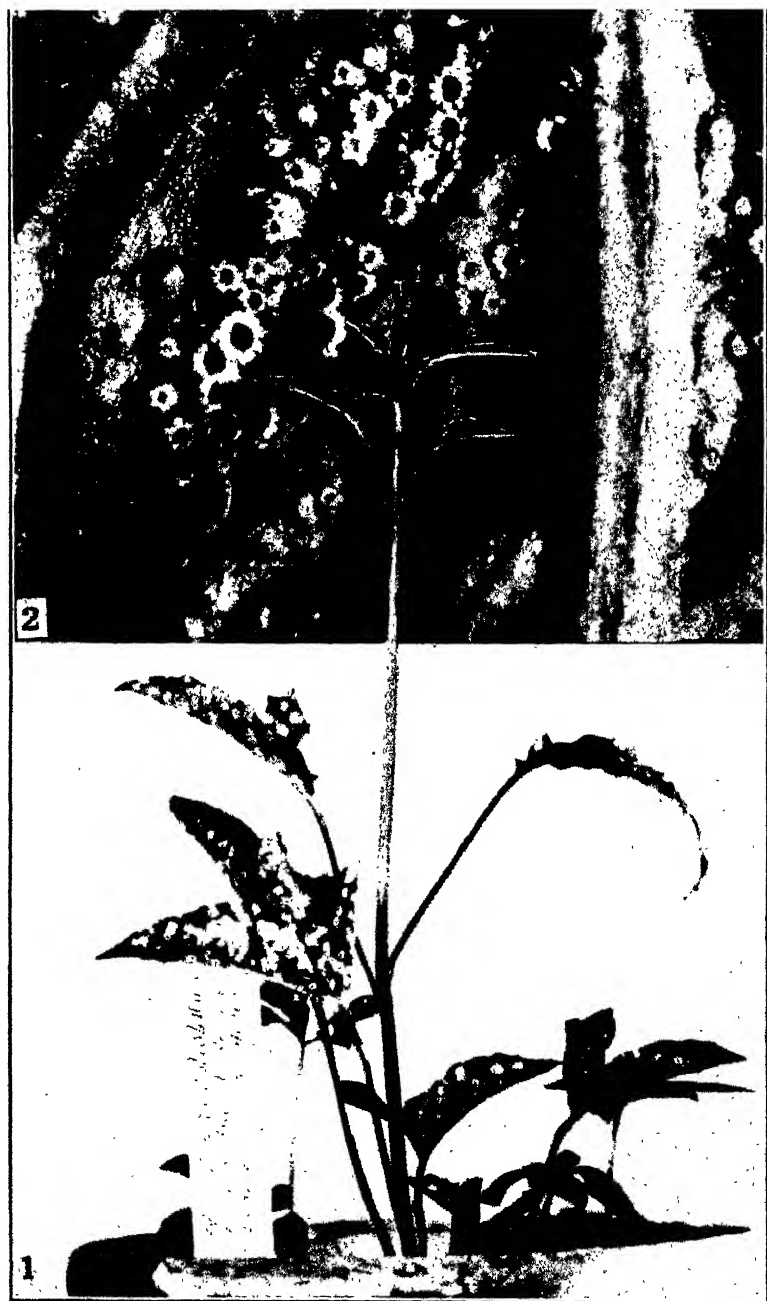
The source of germinating teliospores was rusted *Chrosperma* collected at Freeland in April, 1925; material gathered in December, 1924, and stored out-of-doors at Washington, D. C., was successfully used as inoculum but its viability was less. Aeciospores were obtained from the aecial stage on *Nabalus* produced by inoculation with teliospores on *Chrosperma*. *Nabalus serpentarius* proved to be a thoroughly congenial host. In field inoculations upwards of 50 plants growing within a 10 foot circle about a few rusted *Amianthium* leaves became heavily infected. Similar results were obtained in an inoculation chamber, normal aecia developing in 18 days. The dentate-leaved form, described as *N. integrifolius* Cass., proved equally susceptible, as did also *N. albus* Hook. Simultaneous inoculations failed completely on *Lactuca virosa* L., *L. canadensis* L., and on greenhouse lettuce. Uredinia and telia on *Chrosperma* were produced in about 15 days from aeciospore inoculation, but simultaneous inoculation of *Veratrum viride* Art. and *Stenanthium gramineum* (Ker.) Morong were unsuccessful. Incomplete evidence points to this form being limited to *Nabalus* and *Chrosperma*.

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*NABALUS TRIFOLIOLATUS* INFECTED WITH RUST

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## EXPLANATION OF PLATE 17

Fig. 1. Potted plant of *Nabalus trifoliolatus* inoculated with germinating teliospores of *Puccinia atropuncta* from *Chrosperma muscaetoxicum* April 15, 1924. Pycnia first noted April 28 and aecia May 1. Photographed at Washington, D. C., May, 1924.

Fig. 2. Photograph of under surface of *Nabalus trifoliolatus* showing aecia with revolute and lacerate peridia. From artificially infected leaves. Photographed at Washington, D. C., May, 1924.

## RELATION OF GLYCOGEN TO SPORE-EJECTION

LEVA B. WALKER AND EMMA N. ANDERSEN<sup>1</sup>

(WITH PLATE 18)

One of the many elusive problems concerning fungi is the source of the energy used in the ejection of their spores or spore-masses. A good opportunity to study this problem is afforded by *Sphaerobolus* which, as is well known, hurls its spore-masses farther than any other known fungus. Three forms of *Sphaerobolus* were grown in pure cultures during a period of years while studying their morphology and development. All the forms studied fruited freely, hence an abundance of material was available.

The fruit-bodies of a *Sphaerobolus*, just previous to opening, are spherical in shape, usually about 2 to 3 mm. in diameter, and more or less deeply imbedded in the surrounding mycelium or substratum. (See rounded masses in Pl. 18, figs. 2 and 4.) When mature the outer or peridial parts of the fruit-body break open on top in a stellate manner (Pl. 18, figs. 2 and 4), revealing a spherical ball, the glebal mass, on the inside. This rupture takes place early in the morning. As the morning advances a clear watery fluid accumulates around the glebal mass in the cup formed by the peridial parts. In the meantime a rupture has taken place between two layers in the peridium and the inner of these suddenly inverts itself and in so doing hurls the glebal mass to a height of over 14 feet. The inner peridial region may be seen inverted and appearing as a glistening dome above the outer peridial parts in three places in Plate 18, fig. 4. In one form studied the inner peridial layer frequently is ejected along with the glebal mass.

<sup>1</sup> This paper is an outgrowth of unpublished work on the morphology and development of *Sphaerobolus* that has been carried on by Miss Walker. Credit is due Miss Andersen for the microchemical work upon which this paper is based, for without her assistance and suggestions the microchemical tests could not have been made.

Three distinct regions are easily seen: first, an outer peridial region which always remains attached to the substratum and more or less deeply imbedded in it; second, an inner peridial region which at the time of discharge becomes inverted as a dome above the outer region and which by its sudden change of position hurls the glebal mass; and third, the glebal mass itself.

The outer peridial region of nearly mature fruit-bodies differs in structure in the forms studied. In Plate 18, fig. 1, a median longitudinal section of a nearly mature fruit-body of *Sphaerobolus stellatus* is shown. The outer peridial region consists of the three outer layers "O." The inner peridial region "C" is made up of the so-called "collenchyma" layer which is composed of large cells, much elongated radially, especially at the base of the fruit-body, and a "thread" layer composed of slender tangentially arranged hyphae, while the glebal mass "G" contains spores with intermixed hyphae and surrounded by a dense layer of pseudoparenchyma.

When the fruit-body opens, all of the peridial regions are ruptured down to the glebal region. The opening is made possible by the gelatinization of a layer of cells between the "collenchyma" layer and the glebal mass. As a result of this gelatinization the ball-like glebal mass is separated completely from its peridial cup. In the meantime another layer of cells between the inner and outer peridial regions gelatinizes and allows these two layers to separate up to the tip of the peridial points. After the discharge the peridial parts are seen in the position shown in Plate 18, fig. 3, "C" indicating the inner peridial region and "O" the outer peridial region.

Early observations upon *Sphaerobolus* indicated that the forceful ejection of the spore-mass was due to a high osmotic pressure developed in the "collenchyma" layer. It has been possible to determine by experiments that only the inner peridial region could have any part in effecting the final discharge. (This has also been confirmed by Dr. A. H. R. Buller working independently, according to his verbal statement.) An important fact about the "collenchyma" layer is that up to the time the fruit-body opens the cells are completely filled with a densely granular content which disappears during the few hours inter-

vening between the opening of the fruit-body and the discharge of the spore-mass. Before the discharge takes place, as has been noted, the "collenchyma" layer, together with a few filaments of the "thread" layer, become separated from all other regions in the fruit-body, thus making it possible to study this inner peridial region by itself. These observations lead to the belief that microchemical tests might be applied advantageously in order to determine what changes took place in the "collenchyma" layer and therefore what had given the force for the discharge. Miss Andersen became interested in the work at this point.

Our tests<sup>2</sup> show that the collenchyma layer before and at the time the fruit-body opens is densely filled with glycogen, as has been reported by Errera<sup>3</sup> and others. By the time the discharge takes place the glycogen has been transformed into sugars. (Reducing sugars were abundantly present. Maltose at least could be definitely demonstrated.) This sudden transformation of glycogen which exerts almost no osmotic pressure to sugars with their high osmotic pressure causes an expansion of these collenchyma cells which are free on their inner ends and held tightly together by the "thread" layer on their outer ends. A few of the cells of the "thread" layer also contain glycogen which is seemingly similarly transformed and by the slight swelling of these cells an added tension is developed tangentially. The sudden osmotic expansion of the cells in these two layers causes the inversion of these layers and provides the force for the discharge of the glebal mass. If a fruit-body opens when temperatures are low and the light dim glycogen is transformed to sugars so slowly that the inversion of the "collenchyma" layer takes place very gradually and the glebal mass is left in place on the upturned "collenchyma" layer. On the other hand,

<sup>2</sup> In testing for glycogen, the iodine test was used almost exclusively. For sugars Flückiger's reaction and the phenylhydrazine reaction were used. With the latter reagent frequently some difficulty was experienced in securing osazones. Hydrazones formed readily and abundantly but the osazones sometimes would form and then instead of "feathering out" more and more on standing as with pure chemicals, they would seemingly be dissolved by other substances present and disappear. The best results were obtained with the cold process.

<sup>3</sup> Errera, L., Sur le Glycogene chez les Basidiomycetes, Rec. de l'Inst. Bot., Bruxelles 1: 95. 1885.

if the temperature is at about 90° F. at the time of the opening of the fruit-body and the light is bright, these changes take place so suddenly that the glebal mass may be hurled over fourteen feet vertically into the air. It is interesting to note that the opening of the fruit-body itself is due to the change of glycogen to sugars in an outer layer.

The very definite relation between the transformation of glycogen to sugars and its efficiency in bringing about the ejection of the spore-mass in *Sphaerobolus* led to tests on other fungi to see to what extent such phenomena may occur elsewhere. Young asci and young basidia were found to contain glycogen, and as is well known, it disappears just before the discharge and sugars are present afterward. In long slender asci such as found in *Peziza vesiculosa* the glycogen is usually confined to the part of the ascus below the spores while in broader asci it surrounds the spores also. We have not been able definitely to localize the sugars in sections but in young hymenia before the spores were discharged no sugars were found, while in older hymenia sugars were present. The amount of glycogen in the young asci and basidia varied greatly in different species examined, and although no tests were made to establish the fact, it appears that the amount of glycogen present determines the distance to which the discharge may take place. For example, the asci of Ascobolaceae examined, such as *Lasiobolus*, are much more densely filled with glycogen than those of *Peziza vesiculosa*, *P. badia*, or *Sarcoscypha coccinea*, and these last contain very much more glycogen than species of *Lachnea* and *Humaria* examined. The asci of Pyrenomycetes examined contain only traces of glycogen. In general basidia contain less than asci. In *Pilobolus* glycogen is present in the young sporangiophore and disappears largely before the discharge but no reducing sugars could be definitely demonstrated.

Aside from the rôle of glycogen when transformed into sugars in bringing about spore-ejection similar transformations take place in other parts of fruit-bodies and cause the sudden enlargement of cells that results in the expansion of the fruit-body. For instance, in small, dung inhabiting *Coprini* just before the elongation of the stipe, glycogen is present and disappears during

the enlargement of the cells that produce elongation. The same conditions are noted before and during the expansion of the pileus, trama, etc. One of the most definite tests made was on a young ascocarp of *Peziza vesiculosa* before any spores had matured. All of the smaller cells of the fruit-body were densely filled with glycogen while the larger cells were filled with a reducing sugar. Sections that had been tested by Flückiger's test were washed and then tested for glycogen and very definite localization obtained.

That glycogen is readily changed to maltose if diastase is present is a quite well-established chemical fact, according to Haas and Hill.<sup>4</sup> In our work with *Sphaerobolus* maltosazones were always found. Other sugars may have been present but no dependable results were secured. It seems probable from our tests that different sugars may be formed by different fungi and by the same fungus under different conditions.

As a result of his extensive work on glycogen in all groups of fungi, Errera<sup>5</sup> concludes that glycogen is the reserve carbohydrate of fungi, comparable to starch in higher plants. He observed the transformation of glycogen into sugars during the maturation of tissues, asci, etc. Since glycogen disappears from fungus cells during their enlargement he concludes<sup>6</sup> that it supplies the cell with the substances necessary for growth.

It seems very probable that Errera is correct in believing that glycogen may serve as a reserve carbohydrate, comparable to starch, yet he sets forth little experimental evidence to substantiate his assumption. On the other hand, Miss Ternetz,<sup>7</sup> in her work on *Ascophanus*, shows that the glycogen stored by that fungus cannot be used for its nutrition when no other food is available, at least under the conditions tested. We have no evidence along this line but we feel that we have evidence that one of the primary functions of glycogen, when transformed into sugars, is to create osmotic pressure which results in a sudden

<sup>4</sup> Haas, P., and Hill, T. G., *An Introduction to the Chemistry of Plant Products*. 3d edition. 1: 130. 1921.

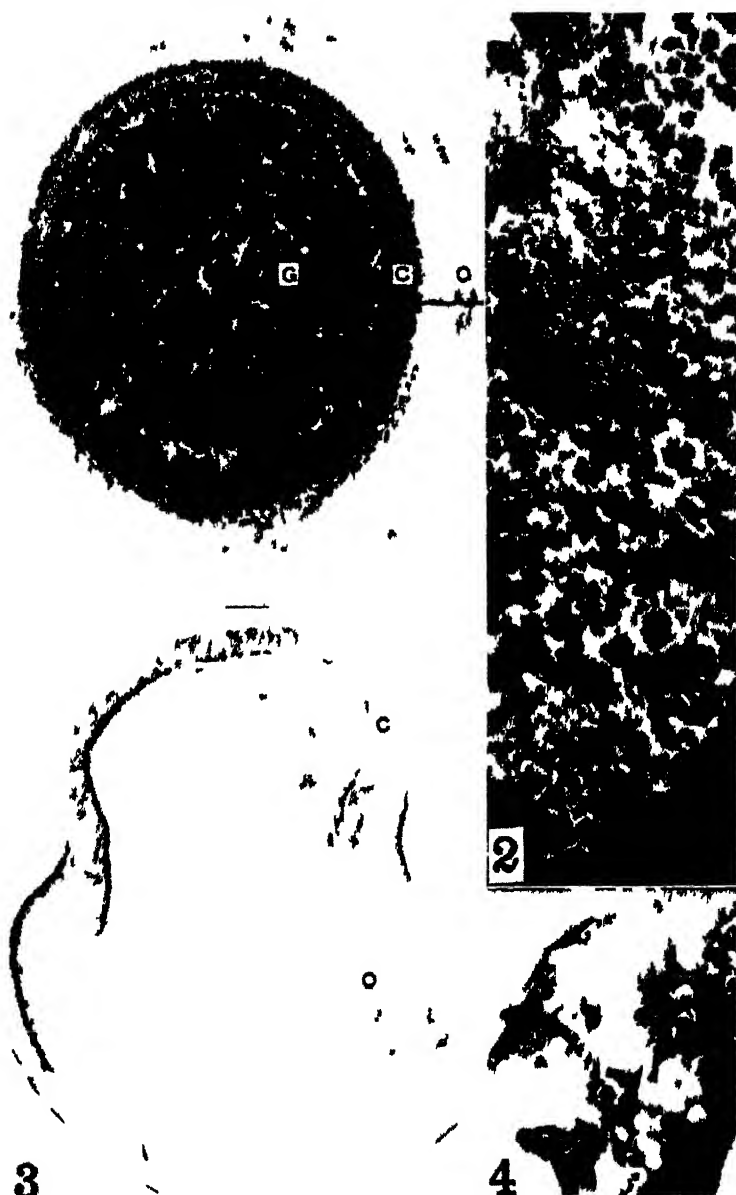
<sup>5</sup> Errera, L., *Sur le Glycogene chez les Basidiomycetes*, Rec. l'Inst. Bot., Bruxelles 1: 1-134. 1885.

<sup>6</sup> Loc. cit. 122.

<sup>7</sup> Ternetz, Ch., *Protoplasmabewegung und Fruchtkörperbildung bei Ascophanus carneus Pers.* Jahrb. f. Wiss. Bot. 35: 276. 1900.







SPHAEROBOLUS

enlargement of cells in vegetative tissues of fungi and is, at least in many cases, the direct cause of the forceful ejection of spores and spore-masses in reproductive parts.

The writers wish to extend grateful acknowledgment to Dr. Sophia Eckerson for reading the manuscript of this paper and to Prof. T. J. Fitzpatrick for reading of manuscript and proof.

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#### EXPLANATION OF PLATE 18

Fig. 1. Photomicrograph of a median longitudinal section of a nearly mature fruit-body of *Sphaerobolus*. *O*, outer peridial region; *C*, inner peridial region; *G*, glebal region.  $\times 37$ .

Fig. 3. Photomicrograph of a median longitudinal section of the peridium of *Sphaerobolus* after the discharge of the glebal mass. *O*, outer peridial region; *C*, inner peridial region.

Figs. 2 and 4. Photographs of cultures of *Sphaerobolus* showing fruit bodies in various stages of development.

# CLUB-ROOT OF CHINESE CABBAGE

W. H. DAVIS

(WITH 1 TEXT FIGURE)

## THE HOST

Chinese cabbage (*Brassica Pe-tsai* Bailey) was introduced into America about 35 years ago and to-day it is one of the closest rivals of our head lettuce. Fairchild<sup>1</sup> has pointed out the advantage of Chinese "petsai" over head lettuce as follows:

1. The cost of production is reduced one-half.
2. It can be grown throughout the country.
3. The keeping qualities are superior.
4. Pound for pound, it may contain equal portions of the desirable food element, "fat soluble A."
5. It is more attractive in appearance.

At the present time Chinese cabbage is not extensively cultivated but, according to Fairchild, it has a future as a salad plant. However, much of the prejudice caused by the term "cabbage" should be removed and the American housewife educated to its use.

## THE DISEASE

In October 1923 the writer had occasion to remove Chinese cabbage plants from the vegetable gardens of the Massachusetts Agricultural College and transplant them in ten-inch pots for experimental work in the greenhouse. The roots of these transplanted plants contained numerous large galls similar to those on common cabbage when infected by *Plasmodiophora Brassicae* Woronin which causes club-root. A previous description of this disease on Chinese cabbage has not come to the writer's attention.

Free-hand sections of these diseased roots on Chinese cabbage showed hypertrophy of the cells in the parenchyma and the usual transitional stages between plasmodium and matured spores which are generally visible in roots parasitized by *P. Brassicae*.

<sup>1</sup> Fairchild, D., The Chinese Petsai as a Salad Vegetable. Jour. Hered. 9: 291-295. 1918.

One of the diseased Chinese cabbage plants of a variety known as "kinshiu" died three days after transplanting. In November, 1923 the pot containing this dead plant together with the soil was stored outdoors near the east wall of the pathologium. In September, 1924 the pot was returned to the greenhouse bench and forty-eight seeds of Chinese "wong bok" were sowed therein. The contents of this pot were subjected to the same conditions of light, heat (20° C.) and moisture as plants growing on the same bench. Sterilized and unsterilized soils from the greenhouse bench placed under the same conditions were employed in the checks.

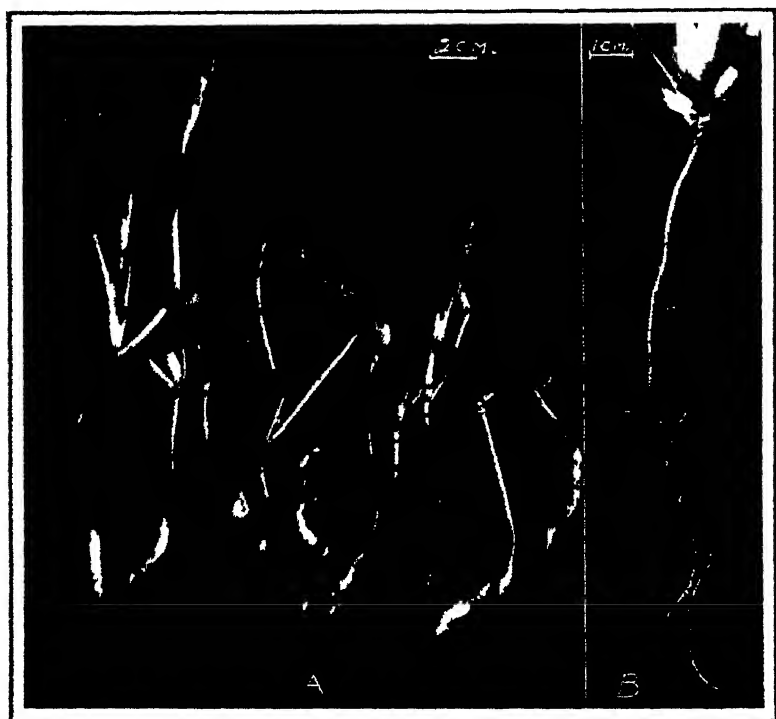


FIG. 1. Photographs of Chinese cabbage plants. A. Roots infected with *Plasmodiophora Brassicae* Woronin causing club-root; B. A healthy root.

On November 15, 1924, thirty-eight plants had developed from the forty-eight seeds and all but one showed symptoms of club-root (Text fig. 1, A). On January 15, 1925, twenty of these

plants had been removed for experimental purposes, seventeen had died and one was still alive. Each one of the thirty-eight plants was infected with *P. Brassicae*. In free-hand sections of these diseased roots, the usual hypertrophy of the cells together with the different morphological structures common to *P. Brassicae* were easily recognized. All plants in the checks appeared healthy (Text fig. 1, B). From the symptoms and spore measurements together with other details described by Woronin<sup>2</sup> the organism was recognized as *P. Brassicae*. Club-root was also observed on Chinese "petsai," "paoting" and "chosen."

From the above observations and experiments it is evident that Chinese "wong bok," "kinshiu," "petsai," "paoting" and "chosen" are hosts for *Plasmodiophora Brassicae* Woronin which causes the disease commonly known as club-root.

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<sup>2</sup> Woronin, M., *Plasmodiophora Brassicae*. Jahrb. f. Wiss. Bot. 11: 548-574. pl. 19-24. 1878.

# THE INHERITANCE OF RESISTANCE OF OAT HYBRIDS TO LOOSE SMUT<sup>1</sup>

GEORGE M. REED

The study of the inheritance of disease resistance constitutes a problem of great economic and scientific interest and numerous investigators have contributed towards its elucidation in various groups of diseases. The present paper is concerned with studies on the inheritance of resistance to the loose smut of oats, *Ustilago Avenae* (Pers.) Jens., in a hybrid between a very susceptible variety, *Avena nuda* L. var. *inermis* (S.N. 30), and a very resistant one, *A. sativa* L. var. *Black Mesdag* (S.N. 70). Although the results here described relate to a single cross, investigations are in progress on additional ones between the same parents, as well as crosses involving other varieties.

A few results on oat smut inheritance have previously been recorded. Wakabayashi (18) has published some data on the behavior of the progeny of a cross between Red Rustproof and Black Tartarian to *Ustilago levis* (K. & S.) Magn., the former being resistant and the latter susceptible to the smut. No smut was observed among the  $F_1$  and  $F_2$  plants. In the  $F_3$  generation, however, twelve families out of a total of ninety-five were observed to contain a few infected individuals. Barney (1) has recorded more extensive data on three different oat crosses. One cross involved two very resistant varieties, Fulghum and Black Mesdag; a second cross was between the resistant Burt and the susceptible Swedish Select; and the third cross was between two susceptible varieties, Turkish Rustproof and Golden Rain. Barney interpreted his results on the basis that resistance in the first cross depended upon three different factors, in the second upon two, and in the third upon only one. Reed and Stanton (16) have described their results with a cross between

<sup>1</sup> Brooklyn Botanic Garden Contributions No. 45. The writer is specially indebted to Lois Davis Van Gorden for valuable assistance in carrying on the studies and preparing the data for publication.

Fulghum and Swedish Select, the former being very resistant to both *Ustilago Avenae* and *U. levis*, while the latter is susceptible to both smuts. The behavior of the  $F_2$  plants was not recorded but of the  $F_3$  progeny studied, some showed a degree of susceptibility corresponding to that of Swedish Select, a few progenies showed a much greater susceptibility, while still others possessed a resistance corresponding to that of Fulghum. No correlation between morphological characters and susceptibility or resistance was observed and they conclude that it is possible to combine resistance to smut with other varietal characters of oats.

#### THE PARENTS AND THE $F_1$ PLANT

*The Female Parent.*—The strain of *Avena nuda* was received from Doctor Franz Bubák, then Director of the Botanic Garden, Tabor, Bohemia, in April, 1913 under the name of *A. nuda* L. var. *chinensis* Fischer. It, however, seems more properly to belong to the variety *inermis*, since there is an almost complete absence of awns of any description.

The hull-less or naked oats are distinguished from the other species of *Avena* by several characteristics: (1) The empty glumes and lemmas are very similar in texture, being thin and membranous; (2) the lemma and palea do not clasp the kernel, the latter remaining loose or free within the chaff and readily separating in threshing; (3) each spikelet of the panicle bears several flowers, varying from four to nine; (4) the rhachillas of the spikelets are much elongated so that the uppermost grains are borne well above the empty glumes.

The young stems of the strain used were erect in growth and a moderate amount of tillering occurred. The average height of the plants to the base of the panicle, grown under greenhouse conditions, was about forty inches. The leaves, light green in color, were rather narrow, the uppermost one averaging slightly more than one half inch in width.

The panicles were equilateral and compact, with a fairly large number of branches. The average length in the plants studied was nine inches. The spikelets of the panicle were many-flowered, usually four to six. The empty glumes and lemma were essentially similar in structure. The awns were absent or, at most, weak awns occurred on the basal flower of a few spikelets.

Hull-less oats have relatively little economic value, although for centuries they have been grown in western China and have served as an important source of food for the natives. In Europe and America they have been largely grown for their botanical interest. They have, however, been used in crossing with other forms of oats and various selections of hulled types from the hybrids have been made which have given rise to cultivated varieties with desirable agronomic characteristics. In recent years the hull-less Liberty oat has been developed by the Ontario Agricultural Experiment Station from a cross between Chinese Hull-less and Swedish Select. This particular variety has quite a large kernel, yields well, and promises to be of considerable economic value.

*The Male Parent.*—The strain of Black Mesdag was also received from Dr. Franz Bubák in March, 1914 under the name of *Avena sativa* L. var. *nigra*. The presence of numerous awns on the plant, however, suggests that it more properly belongs in the variety *montana* and appears to be identical with Black Mesdag.

The culms of the plant were erect in early growth and relatively little tillering occurred; they were large, coarse and glabrous. The average height to the base of the panicle, when grown under greenhouse conditions, was forty-two inches. The leaves were dark green, with smooth margins, the uppermost one to one and one half inches wide.

The panicles were equilateral, wide spreading and very lax, drooping or nodding from the middle outward, varying in length from fifteen to eighteen inches, with relatively few branches. The spikelets bore two grains, rarely three. The lemmas were brownish black, elongated, glabrous, with seven rather obscure nerves. Well developed awns were usually present on the lower grain of each spikelet. The bases were twisted, frequently geniculate. Occasionally a few hairs, one to two mm. long, fine and weak, occurred at the base of the outer kernel. The rhachilla of the outer grain was two to three mm. long, with long, stiff hairs.

Black Mesdag is a medium early maturing oat. To some extent it is grown by farmers but it is not regarded as having any special merit.



*The F<sub>1</sub> Hybrid.*—The F<sub>1</sub> plant was grown under greenhouse conditions. The young stems were erect; four stalks developed to maturity, the main stalk being thirty-eight and one-fourth inches high to the base of the panicle, with eight internodes. The leaves were dark green in color and wide, thus resembling the Black Mesdag parent.

The panicle was fifteen and three fourths inches long, spreading and drooping somewhat from the middle outwards. In general shape it resembled the Black Mesdag parent but there was a larger number of branches and spikelets. The spikelets were all many-flowered, the number of grains produced being from one to five. The empty glumes and lemmas were entirely similar to those of *Avena nuda*, pale yellow in color and membranous in texture; the paleae, however, were dark. The grains were held loosely within the glumes, readily falling out in threshing. Very weak or feeble awns were present on the basal flowers of a few spikelets. They were slightly more numerous than on the hull-less parent but no well developed awns with twisted bases were present. The plant was very fertile, approximately five hundred kernels being produced.

In general the plant resembled a somewhat more robust type of the hull-less parent. The broader leaves, the longer, more lax and drooping panicle, together with the dark color of the palea, were the most marked points of difference. It is especially noteworthy that there was a complete absence of any indication of an intermediate condition in the character of the spikelets, such as has been described by other investigators who have crossed hulled and hull-less oats.

#### RESISTANCE AND SUSCEPTIBILITY OF THE PARENTS TO *USTILAGO AVENAE*

Reed (12) and Reed, Griffiths and Briggs (15) have published extensive data on the behavior of oat varieties to both loose and covered smuts. The particular strain of *Avena nuda* (S.N. 30) used as the female parent in this cross has been grown for a number of years under very diverse conditions and its behavior towards *Ustilago Avenae* has been very fully determined, especially with reference to the Missouri strain of this smut as

described by Reed (13). Under field conditions, 4,592 plants have been grown over a period of eleven years; 3,284 of these plants, or 71.5 per cent, were infected. It would not be unusual to find all the plants in the row entirely smutted, although frequently one or more escaped. In the greenhouse, where the conditions in general were more favorable for infection by the smut, higher percentages of infected plants have been obtained. In various experiments, 297 plants have been grown, of which 260, or 87.5 per cent, have been infected. The variety Black Mesdag (S.N. 70) presents a complete contrast to the hull-less oat with reference to its behavior to *Ustilago Avenae*, as it has shown a remarkable degree of resistance. Under field conditions, over a period of nine years, 4,270 plants have been grown, of which only four have been infected. In the greenhouse, 295 plants have been grown and none have been infected. These figures include the data published in the papers just referred to as well as additional data more recently obtained.

#### EXPERIMENTAL RESULTS WITH THE $F_2$ GENERATION

The seed which developed into the  $F_1$  plant was not inoculated for the obvious reason that, if infection occurred, seed formation would be prevented and further continuance of the experiment made impossible. The fact that infection with this smut takes place in the seedling condition, and that, if it does occur, it is likely to result in the complete destruction of the grain, makes necessary certain modifications in the procedure of analyzing the inheritance of resistance. Consequently, in the  $F_2$  generation, as well as the subsequent ones, only a portion of the seed was inoculated, additional uninoculated plants being grown with a view to obtaining sufficient plants for the study of spikelet and other characters and for propagation in successive generations.

Bartholomew and Jones (2), and Reed and Faris (14) have determined the influence of certain environal factors on infection of oats by smuts. It has been found that a relatively dry soil and a temperature of about 20° C. are very favorable for infection of oats by both loose and covered smut. Although infection takes place over a comparatively wide range of temperature and moisture the highest percentages are secured under the particular

conditions just mentioned. In the experiments with the hybrid the dry seed was inoculated by dusting with the dry spores. The seed was then germinated in sand with a low percentage of moisture and either in the constant temperature tank at 20° C. or in the greenhouse where the temperature averaged near to 20° C. In some cases the seedlings were transplanted and grown to maturity in the greenhouse, while in other experiments the germinated seedlings were transplanted to the field where they matured. In all the plantings of the hybrids inoculated seed of both parents was also grown for the purposes of direct comparison.

Eighty-two  $F_2$  plants matured from inoculated  $F_1$  seed and accordingly had a chance to become infected in the seedling stage and develop the characteristic smut lesions in the adult plant. Twenty-five of these plants were grown to maturity in the greenhouse and the remaining fifty-seven in the field. The data on the infection of these plants, as well as the two parents grown simultaneously, are shown in Table I.

TABLE I  
DATA OBTAINED WITH INOCULATED  $F_2$  PLANTS

	Hybrid			<i>Avena nuda</i>			Black Mesdag		
	No. plants	No. inf.	Per cent inf.	No. plants	No. inf.	Per cent inf.	No. plants	No. inf.	Per cent inf.
Greenhouse . . .	25	5	20.0	30	27	90.0	25	0	0
Field . . . . .	57	16	28.0	143	137	95.8	75	0	0
Total . . . . .	82	21	25.6	173	164	94.7	100	0	0

As seen from the table, twenty-one plants out of a total of eighty-two, constituting 25.6 per cent, were infected. Under the same conditions, the resistant parent, Black Mesdag, gave one hundred plants, none of which were infected. On the other hand, one hundred seventy-three plants of the susceptible *Avena nuda* were grown and one hundred sixty-four, or 94.7 per cent, were infected. These results indicate that the conditions were exceedingly favorable for the infection of susceptible plants.

The data indicate rather clearly that resistance to the smut is a dominant character and that susceptibility is recessive and, further, that these characters depend upon a single factor difference. To be sure, the number of plants is not especially large but the approximation to this interpretation is exceptionally close.

#### OBSERVATIONS ON THE BEHAVIOR OF THE $F_3$ GENERATION

*Results with  $F_3$  Families of Resistant  $F_2$  Plants.*—Naturally, no further study of the susceptible  $F_2$  plants was made, since the floral parts were completely destroyed and no grain developed. The behavior, however, of most of the surviving sixty-one resistant  $F_2$  plants was determined in the  $F_3$  generation. For various reasons the progeny of nineteen of them was not studied, the behavior of the progeny of the remaining forty-two being carefully observed. The seed from thirteen of these was inoculated, germinated in sand at room temperature and later transplanted to the field where they grew to maturity. The seed of the remaining twenty-nine was also inoculated, germinated in sand with 30 per cent moisture in the constant temperature tank at 20° C. and grown to maturity in the greenhouse. Since the seed of some of these  $F_2$  plants was hulled and that of others hull-less, the hulls from the former were removed before inoculation.

In Table II are recorded the data on the behavior of the  $F_3$  progeny of these forty-two resistant  $F_2$  plants. If the view that smut resistance in this cross depends upon a single factor, as indicated by the results of Table I, is correct we should find in the  $F_3$  progeny only two classes of families, namely, those which are entirely resistant and those which are segregating with reference to smut resistance in an approximately three to one ratio. The theory also requires that the two classes of progenies, resistant and segregating, should be represented in the ratio of one of the former to two of the latter. There should be no families in which all the individuals were susceptible to the disease, since the  $F_2$  plants carrying the factor for susceptibility have been prevented from seed formation by the parasite and consequently eliminated from producing progeny in the following generation.

It is possible, however, that one or more susceptible  $F_2$  plants may have escaped infection and consequently their freedom from smut was not due to real resistance. As presented later, there is some evidence that this actually occurred.

TABLE II  
RESULTS WITH  $F_1$  FAMILIES OF RESISTANT  $F_2$  PLANTS

$F_2$ plant		Results with <i>Ustilago Avenae</i>			$F_2$ plant		Results with <i>Ustilago Avenae</i>		
Number	Grain type of panicle	No. plants	No. inf.	Per cent inf.	Number	Grain type of panicle	No. plants	No. inf.	Per cent inf.
<i>Segregating <math>F_2</math> families</i>									
1	Naked *	19	3	15.7	120	Naked	25	7	28.0
3	Hulled	46	18	39.1	124	Hulled	24	6	25.0
4	Naked *	50	15	30.0	125	Naked *	24	5	20.8
5	"	13	3	23.0	126	" *	23	9	39.1
10	Hulled	36	18	50.0	127	Hulled	23	8	34.7
15	"	17	1	5.8	128	"	23	8	34.7
104	"	21	3	14.2	129	Naked *	18	4	22.2
105	Naked	24	5	20.8	132	Hulled	23	9	39.1
106	"	24	7	29.1	133	Naked *	25	8	32.0
107	"	24	4	16.6	135	" *	25	6	24.0
109	" *	24	4	16.6	136	Hulled	26	10	38.4
111	" *	25	5	20.0	138	"	25	3	12.0
115	" *	25	5	20.0	140	Naked *	23	4	17.3
116	" *	12	5	41.6	141	" *	23	3	13.0
117	Hulled	21	7	33.3	142	" *	22	7	31.8
<i>Resistant <math>F_2</math> families</i>									
2	Naked *	43	0	0	24	Naked *	15	0	0
6	Hulled	20	0	0	102	" *	23	0	0
7	Naked *	11	0	0	118	" *	26	0	0
9	" *	70	0	0	122	" *	18	0	0
16	" *	29	0	0	134	Hulled	21	0	0
17	" *	5	0	0	137	"	24	0	0

The  $F_2$  plants are indicated on the basis of whether the panicle contains many-flowered naked-grains or few-flowered hulled-grains. The panicle of the first may also contain spikelets of the hulled type.

The \* indicates that the  $F_2$  progeny contains both panicle types.

An examination of Table II discloses the interesting fact that thirty of the  $F_2$  families gave progeny which was segregating for resistance to smut. The percentage of infection in these

families varied from 5.8 per cent in No. 15 to 50 per cent in No. 10. The percentage of infection in the latter was rather high, in this particular progeny a total of thirty-six plants being grown, of which eighteen were infected. The average for all the families, however, is quite close to a 1 to 3 ratio. Further, the remaining twelve  $F_2$  plants gave progeny which were entirely resistant, no infection occurring in any individual of these families; finally no families were found in which all the individuals were highly susceptible. If, on the basis of these data, we arrange the results in tabular form, we obtain the following:

	Total	Segregating	Resistant	Susceptible
Expected	42	28	14	0
Observed	42	30	12	0

We thus see that these results are in close correspondence with the data obtained with the  $F_2$  plants.

*Results with  $F_3$  Families of Uninoculated  $F_2$  Plants.*—In addition to the  $F_3$  progeny of the resistant  $F_2$  plants just described, studies were made with the progenies of fifty-eight  $F_2$  plants which had not been inoculated. Among these we would expect the appearance of three classes: (1) all the individuals susceptible; (2) all the individuals resistant; and (3) a class in which the progenies show segregation for smut resistance. Further, these three groups should appear in the ratio of one susceptible, two segregating and one resistant.

An examination of Table III reveals the fact that twenty-eight of these fifty-eight  $F_3$  families show segregation, the percentage of infection ranging from 3.8 per cent in No. 49 to 58.5 per cent in No. 28. Further, the progeny of eighteen of the plants were pure resistants, no infection occurring in any individuals. Finally, the progeny of the remaining twelve plants may be classified as susceptible, since a large proportion of the individuals were infected by the parasite. In this group the percentage of infection varied from 81.8 to 100 per cent, all the individuals of nine of the twelve families being attacked.

The question may be raised as to whether family No. 28 should be classified in the segregating or susceptible group. The per-

TABLE III  
RESULTS WITH *F*, FAMILIES OF UNINOCULATED *F*<sub>2</sub> PLANTS

<i>F</i> plant		Results with <i>Ustilago A. enue</i>			<i>F</i> <sub>2</sub> plant		Results with <i>Ustilago Aenae</i>		
Num- ber	Grain type of panicle	No. plants	No int	Per cent int.	Num- ber	Grain type of panicle	No. plants	No. int.	Per cent inf.
<i>Segregating F<sub>2</sub> families</i>									
28	Hulled	41	24	58.5	55	Hulled	9	3	33.3
30	"	51	4	7.8	58	Naked	3	1	33.3
31	Naked *	73	15	20.5	62	" *	28	5	17.8
32	" *	19	5	26.3	64	" *	4	2	50.0
34	" *	145	36	24.8	78	Hulled	28	4	14.2
35	Hulled	62	6	9.6	81	"	36	2	5.5
37	"	44	3	6.8	88	Naked *	16	1	6.2
39	Naked *	69	23	25.8	89	" *	37	9	24.3
41	"	12	3	25.0	90	" *	69	10	14.4
48	"	8	3	37.5	145	"	24	11	45.8
49	Hulled	26	1	3.9	149	" *	14	5	35.7
50	Naked *	3	1	33.3	150	Hulled	23	4	17.3
52	"	43	13	30.2	153	Naked	24	9	37.5
53	Hulled	44	6	13.6	158	"	27	8	29.6
<i>Resistant F<sub>2</sub> families</i>									
29	Naked *	30	0	0	80	Naked	9	0	0
38	Hulled	15	0	0	82	" *	8	0	0
42	Naked *	26	0	0	84	Hulled	4	0	0
46	Hulled	7	0	0	85	Naked *	19	0	0
54	"	8	0	0	101	" *	18	0	0
69	Naked *	35	0	0	148	" *	23	0	0
70	" *	57	0	0	151	" *	25	0	0
74	" *	12	0	0	154	" *	23	0	0
75	" *	23	0	0	159	" *	22	0	0
<i>Susceptible F<sub>2</sub> families</i>									
27	Naked *	10	9	90.0	77	Hulled	11	9	81.8
40	Hulled	29	24	82.7	91	Naked *	18	18	100.0
47	Naked *	48	48	100.0	93	"	3	3	100.0
57	" *	35	35	100.0	147	Hulled	22	22	100.0
60	" *	7	7	100.0	152	Naked	25	25	100.0
63	" *	16	16	100.0	155	"	22	22	100.0

The *F*<sub>2</sub> plants are indicated on the basis of whether the panicle contains many-flowered naked-grains or few-flowered hulled-grains. The panicle of the first may also contain spikelets of the hulled type.

The \* indicates that the *F*<sub>2</sub> progeny contains both panicle types.

centage of infection 58.5 per cent is rather low for a highly susceptible family but is equally high for a segregating one. The number of individuals grown, however, was fairly large, namely, forty-one. In order to determine to which class this family actually belongs it is necessary to study the subsequent generation which, in part, has been possible.

In tabular form the results for the fifty-eight families appear as follows:

	Total	Resistant	Segregating	Susceptible
Expected	58	14.5	29	14.5
Observed	58	15	28	12

The facts observed are in fairly close harmony with the theoretical requirements, although there are a few too many resistant families. In view of the total number of plants, however, the variation is not exceptional.

#### RESULTS OBTAINED WITH THE F<sub>4</sub> GENERATION

*Results with the Descendants of Resistant F<sub>3</sub> Families.*—As yet the F<sub>4</sub> descendants of only a few of the F<sub>3</sub> plants have been grown and consequently, the data are insufficient to draw any final conclusions as regards their behavior to *Ustilago Avenae*. However, the facts obtained are interesting in their general bearing upon the problem and are worth being noted.

In Table IV there are recorded the results obtained with the F<sub>4</sub> progeny from nine resistant F<sub>3</sub> families. In each case the seed of six different F<sub>3</sub> plants was inoculated and the individuals grown to maturity in the greenhouse. Seven of these progenies (Nos. 2, 6, 7, 9, 16, 17 and 24) are descended from inoculated F<sub>2</sub> plants, the remaining two progenies (Nos. 29 and 38) not being tested in the F<sub>2</sub> generation.

As noted from the table all the F<sub>4</sub> individuals in these progenies from the nine F<sub>3</sub> families were entirely resistant. More than 100 plants of each were grown and in a total of 1,025 plants not one was observed to be infected.

*Results with the Descendants of Susceptible and Segregating F<sub>3</sub> Families.*—The F<sub>4</sub> progeny from only one susceptible F<sub>3</sub> family,



TABLE IV  
RESULTS OBTAINED WITH THE F<sub>4</sub> GENERATION DESCENDED FROM NINE  
RESISTANT F<sub>3</sub> FAMILIES

Number of F <sub>3</sub> plant	Results with <i>Ustilago avenae</i>		Number of F <sub>4</sub> plant	Results with <i>Ustilago avenae</i>	
	No plants	No infected		No plants	No infected
2*	113	0	17*	103	0
6*	112	0	24*	116	0
7*	117	0	29	112	0
9*	114	0	38	118	0
16*	120	0			

In each case the progeny of six different F<sub>3</sub> plants was grown. Those indicated by the \* descended from inoculated F<sub>3</sub> plants.

No. 40, has been grown. In the F<sub>3</sub> this family gave, out of a total of twenty-nine plants, twenty-four infected, or 82.7 per cent. The seed used in growing the F<sub>4</sub> generation came from uninoculated F<sub>3</sub> plants and not from the survivors of the previous test. As seen from Table V, the individuals were highly susceptible. A total of one hundred and sixteen plants, descended from the six different F<sub>3</sub> individuals, were grown, of which one hundred and fifteen, or 99.1 per cent, were infected, only one plant escaping and producing abundant seed.

The F<sub>4</sub> progeny of fourteen segregating F<sub>3</sub> families was grown, the descendants of six different F<sub>3</sub> plants being tried in each case. Since the individual F<sub>3</sub> plants from which the seed was taken had not been inoculated we might expect to find in the F<sub>4</sub> progeny three classes represented, namely, resistant, susceptible and segregating. The F<sub>4</sub> descendants of family No. 10 all proved to be susceptible, one hundred and sixteen plants being obtained from the six parents, and of these, one hundred and fifteen or 99.1 per cent being infected. This family in the F<sub>3</sub> generation gave a percentage of infection of 50, eighteen plants out of a total of thirty-six being attacked. This of course was rather high for a segregating family; on the other hand, it was exceptionally low for a susceptible group. The evidence from the fourth generation, however, indicates that it is probably a susceptible progeny and that the inoculated F<sub>3</sub> plant, as well as 50 per cent of the inoculated F<sub>3</sub> plants, escaped infection.

The progeny of the  $F_3$  families Nos. 3 and 28 also showed an excess of highly susceptible individuals. In No. 3 the progeny of five plants was all susceptible, eighty-five individuals being grown. The progeny from the remaining plant, however, gave 18.7 per cent infection, or three infected plants out of a total of sixteen. In the case of No. 28 the progeny of four of the  $F_3$  plants proved to be entirely susceptible, fifty-seven plants being

TABLE V

RESULTS OBTAINED WITH THE  $F_4$  GENERATION DESCENDED FROM ONE SUSCEPTIBLE AND FOURTEEN SEGREGATING  $F_3$  FAMILIES

Number of $F_2$ plant	No. of $F_4$ families grown	Results with <i>Ustilago Avenae</i>			Number of $F_2$ plant	No. of $F_4$ families grown	Results with <i>Ustilago Avenae</i>		
		No. plants	No. inf.	Per cent inf.			No. plants	No. inf.	Per cent inf.
40	6	116	115	99.1	32	1	20	6	30.0
1*	2	30	30	100.0		1	18	3	16.6
	1	20	5	25.0		1	20	3	15.0
	1	18	4	22.2		1	20	2	10.0
	1	18	3	16.6		1	19	1	5.2
	1	17	2	11.7		1	18	0	0
3*	5	85	85	100.0	34	1	20	19	95.0
	1	16	3	18.7		1	20	8	40.0
4*						1	18	7	38.9
	2	40	40	100.0		1	18	7	38.9
	1	20	7	35.0		1	20	6	30.0
	1	20	7	35.0		1	18	5	27.8
	1	20	4	20.0	35				
10*	1	20	0	0		1	18	7	38.8
						1	14	5	35.7
	6	116	115	99.1		1	18	2	11.1
15*	3	34	33	97.0	37	3	52	0	0
	3	55	0	0		1	19	19	100.0
28						1	19	3	15.7
	4	57	57	100.0		1	20	1	5.0
	1	20	11	55.0	39	3	59	0	0
30	1	19	5	26.3					
						1	7	7	100.0
	3	48	47	97.9		1	19	6	31.5
31	1	19	4	21.4		1	21	5	23.8
	2	36	0	0		1	20	4	20.0
						2	39	0	0
41	1	18	18	100.0	41	3	61	59	96.7
	1	16	3	18.7		1	21	5	23.8
	1	17	3	17.6		2	40	0	0
	1	19	2	10.5					
	2	39	0	0					

No. 40 was susceptible in the  $F_2$  generation, all the others segregating. Those indicated by the \* descended from inoculated  $F_2$  plants.

grown and all being infected. The progeny from one additional plant gave a rather high percentage of infection for a segregating group, namely, 55 per cent, eleven plants out of a total of twenty being infected. The descendants of the sixth plant gave 26.3 per cent infection, or five plants out of a total of nineteen.

The remaining eleven  $F_3$  families represented contained progenies which segregated in a ratio more or less closely approximating three to one; the percentage of infection, however, varied from as low as 5 per cent to as high as 40 per cent. Nine of these eleven groups contained progenies of plants which were highly susceptible, two of them, Nos. 32 and 35, not containing any highly susceptible group; nine also contained highly resistant progenies, Nos. 1 and 34 not containing any  $F_4$  family in which all the individuals were resistant.

The data on these eighty-four progenies may be summarized as follows:

	Total	Resistant	Segregating	Susceptible
Expected . . . . .	84	21	42	21
Observed . . . . .	84	19	33	32

Both the parents were grown for direct comparison with the  $F_4$  generation, being subjected to exactly the same treatment. The susceptible *Avena nuda* gave 100 per cent infection, eighteen plants being grown. On the other hand, no infected plants of Black Mesdag out of a total of twenty-two were observed.

Although the data are limited, it is interesting that these various groups of  $F_4$  progenies have behaved in a manner somewhat closely approximating the requirements of a theoretical interpretation of a three to one ratio.

If we now combine the data recorded in Tables I, II and III in order to determine the proportion of resistant, segregating and susceptible  $F_2$  plants, bringing together the facts observed on the inoculated  $F_2$  generation with those obtained from the  $F_3$  progeny of both inoculated and uninoculated  $F_2$  plants, we obtain the following results:

	Total	Resistant	Segregating	Susceptible
Expected . . . . .	140	35	70	35
Observed . . . . .	121	30	58	33

The total of observed plants in the last line omits the progeny of nineteen inoculated  $F_2$  plants which were not followed out in the subsequent  $F_3$  generation. In view of the results recorded in Table II, all, or at least most of these, would probably fall in the segregating and resistant classes.

#### MORPHOLOGICAL CHARACTERISTICS AND SMUT RESISTANCE

It is not within the scope of the present paper to describe in detail the inheritance of the morphological characters of this cross. The two parents, as already noted, differ in a large number of features. The inheritance of such characters as many-flowered and few-flowered spikelets, which appear to be linked with naked and hulled grains, the presence or absence of awns, the color of the lemma, have been described for various oat crosses by a number of investigators. In general the facts observed in the present cross are in harmony with those recorded by Norton (11), Nilsson-Ehle (9, 10), Zade (19), Surface (17), Gaines (5), Love and Fraser (7), Zinn and Surface (20), Caporn (3), Love and Craig (6), Fraser (4), and Love and McCrostie (8).

I have already emphasized the fact that the  $F_1$  plant did not show the intermediate type of spikelet as described by other workers who have studied crosses involving a many-flowered hull-less grained oat as one of the parents. However, among the  $F_2$  plants there were several which had panicles of the so-called intermediate type. The spikelets in the terminal part of the panicle were of the many-flowered type while those at the base and inner part of the panicle were of the few-flowered hulled type. Some of the spikelets also had naked grains in the basal flowers and hulled grains in the upper. The characteristic types described by Caporn (3) as "hardbacks" and "semi-looses" have also been observed among the  $F_2$  plants as well as in their progeny. It is difficult to follow out the inheritance of the presence or absence of awns, as this is complicated by the thin membranous lemma in the *nuda* type which does not appear able to support the development of a complete awn. The problem of the inheritance of lemma color is also complicated because of the fact that the thin membranous lemma of the

hull-less type does not seem to be dark in color. My own observations, however, convince me that the inheritance of the color of the lemma and of the palea are independent, for it has been frequently observed that hulled types of oats have segregated out in which the lemma was light and the palea dark as well as the more familiar types of dark lemma and palea or light lemma and light palea. It is also evident that the presence of color in the lemma is due to more than one factor, for various degrees of color may be present—gray, dark gray, light brown, dark brown, black—in the lemma of the plants.

All of my data indicate clearly that the few-flowered hulled type of spikelet is recessive and, when once segregated out, the individuals breed true for this character. On the other hand, the plants with the characteristic many-flowered spikelets may breed true or may segregate into the different types; the plants with the intermediate type of panicle all show segregation for spikelet character in the subsequent generations.

My data are sufficiently complete for comparing the occurrence of the many-flowered naked grain type of spikelet, characteristic of the susceptible parent, and also the few-flowered hulled grain type of the highly resistant Black Mesdag with resistance to smut. In Table II there are listed the  $F_3$  progeny of thirty  $F_2$  plants which showed segregation for smut resistance. The spikelet characters of the  $F_2$  parents are also indicated. Nineteen had the many-flowered hull-less grain type of spikelet, the  $F_3$  progeny of fourteen of these showing segregation for this character. The remaining eleven  $F_2$  plants had the few-flowered hulled grain type. In the same table there are listed twelve resistant  $F_3$  families; the  $F_2$  parent of nine had the many-flowered-naked grain type of spikelet, all segregating in the  $F_3$ , and the remaining three had the few-flowered hulled grain type. Similar data are shown in Table III for additional  $F_2$  plants. Here we find that the numbers of many-flowered and few-flowered  $F_2$  plants are as follows: (1) Segregating for smut resistance—eighteen with many-flowered and ten with few-flowered; (2) resistant to smut—fourteen with many-flowered and four few-flowered; (3) susceptible to smut—nine with many-flowered and three few-flowered.

Arranged in tabular form these data appear as follows:

Behavior of F <sub>2</sub> progeny to smut	Total No. of progenies	Spikelet character of F <sub>2</sub> plants	
		Many-flowered naked grain	Few-flowered hulled grain
Segregating (Table II) . . . .	30	19	11
Resistant (Table II) . . . .	12	9	3
Segregating (Table III) . . . .	28	18	10
Resistant (Table III) . . . . .	18	14	4
Susceptible (Table III) . . . . .	12	9	3
	100	69	31

These data do not suggest that there is any definite linkage between the factors for the spikelet and grain characters and smut resistance.

Several types have already been segregated out in the F<sub>4</sub> generation in which all the individuals are similar in certain characters. Some of these are practically identical with the original Black Mesdag in spikelet and grain characters, the presence of well-developed awns, and the dark-colored lemma and palea, but which are either highly susceptible or highly resistant to smut. There have also been isolated true breeding types of the hull-less oats which seem to possess all the marked resistance of the original Black Mesdag, although there is a close resemblance in the spikelet characters between those of the susceptible parent. It is, of course, difficult to segregate out types closely resembling either parent in a number of morphological features; the differences between these two varieties are too many for a ready synthesis of the original characters. The F<sub>4</sub> individuals accordingly usually contain various combinations of the characters of the original parental types.

We have, however, both resistant and susceptible F<sub>4</sub> progenies of which all the individuals are alike as to the following characters:

1. Many-flowered hull-less grained spikelet, light-colored palea.
2. Many-flowered hull-less grained spikelet, dark-colored palea.
3. Few-flowered hulled grained spikelet, dark lemma and dark palea.

4. Few-flowered hulled grained spikelet, light lemma and light palea.
5. Few-flowered hulled grained spikelet, light lemma and dark palea.

The number of types of progenies, both resistant and susceptible, is further increased when the presence or absence of well-developed or weak awns is included. While sufficient data have not been presented to statistically establish the absence of linkage between any morphological character and smut resistance, yet it is clear that the quality of resistance may be present in an individual with various combinations of factors for morphological characters.

### CONCLUSION

The data presented indicate quite clearly that, in this cross between the very susceptible *Avena nuda* L. var. *inermis* (S.N. 30) and the resistant *A. sativa* L. var. Black Mesdag (S.N. 70), resistance to *Ustilago Avenae* is dominant while susceptibility is recessive. The facts are also in close accord with the interpretation that there is a single factor difference between the two parents. It is also evident that various combinations of morphological characters and smut resistance may be obtained and a whole series of new types of resistant oats, some with hull-less and some with hulled grain, developed.

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## NOTES AND BRIEF ARTICLES

Dr. J. C. Arthur, of Purdue University, Lafayette, Indiana, recently spent a few days at the New York Botanical Garden, conferring with the editor of *North American Flora*, regarding the publication of rust manuscript which is nearly completed.

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Dr. and Mrs. N. L. Britton accompanied by Mr. Kenneth R. Boynton, Head Gardener of the New York Botanical Garden, have recently returned from Porto Rico, and the Virgin Islands, with additional collection of plants, including some fungi.

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Dr. James R. Weir, Pathologist in Charge of Pathological Collections, Bureau of Plant Industry, has completed a two months' period of service with the Tropical Plant Research Foundation on a survey of sugar cane fungi in Cuba and afterwards collected and studied the diseases of tropical plants in Haiti, the Dominican Republic, and Puerto Rico.

Hon. Carlos E. Chardon, Commissioner of Agriculture and Labor of Porto Rico, was a recent caller at the New York Botanical Garden. Mr. Chardon, a graduate of Cornell University, is a trained mycologist and is collaborating in the work of preparing a check list of Porto Rican fungi, which is to be published by the New York Academy of Sciences. The main object of his visit to the states was to look after details in connection with the proposed embargo on certain Porto Rican fruits.

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Mrs. Mary H. Holway, wife of the late E. W. D. Holway, recently visited the Garden to talk over matters relating to her husband's work. Mrs. Holway accompanied and assisted her husband on his last trip to South America which resulted in bringing back large quantities of valuable fungi. We understand

that these are to be carefully studied by experts in various groups, especially the rusts, and the results to be published later.

#### FUNGI AT LYNCHBURG, VIRGINIA

During the latter half of July, 1924, the writer made frequent excursions to the fields and woodlands in and about Lynchburg, to study trees, flowers, and fleshy fungi. The first visit to an oak grove in Rivermont afforded a surprise in the unusual abundance of the common edible species of *Chanterel*, a basketful of which was collected for the table. On the way to the mountains north of the town, several black locust trees were found infected with *Trametes robiniophila*, a white polypore first described from Falls Church, Virginia; while almost every tree of this kind in the state seems to harbor the very destructive *Pyropolyporus Robiniae*.

An afternoon spent in the spacious grounds of the Orphanage yielded a number of interesting things, among them *Russula compacta*, *R. foetens*, *R. Mariae*, *R. virescens*; *Lactaria piperata* in great abundance; *Venenarius phalloides*, *V. solitarius*; and several rarer species.

On July 27, I spent the day with several friends on an excursion to the westward and southward, covering over one hundred miles and making several stops for collecting fungi. We first drove due west about fifty miles, crossing Otter River and Goose Creek on old covered bridges. The day was fine and the roads at their best. *Coreopsis*, *Saponaria*, and the towering stalks of the common mullein brightened the roadsides. Blackberries and huckleberries were unusually common; while wild plums, peaches, and early apples were ours for the picking.

The most abundant fungus noticed was *Lactaria piperata*; the handsomest, *Venenarius solitarius*, which could be seen in conspicuous ghostly groups as we drove through the woods; while the most interesting was probably *Ceromyces Betula*, with tall, grooved stipe and reddish, viscid pileus. Another rare southern species found, collected by me previously only at Blacksburg, Virginia, was *Vaginata parvicolvata*, a colored plate of which appears as the frontispiece of Marshall's book. Among other specimens collected were: *Lactaria lactiflua*, *Russula*

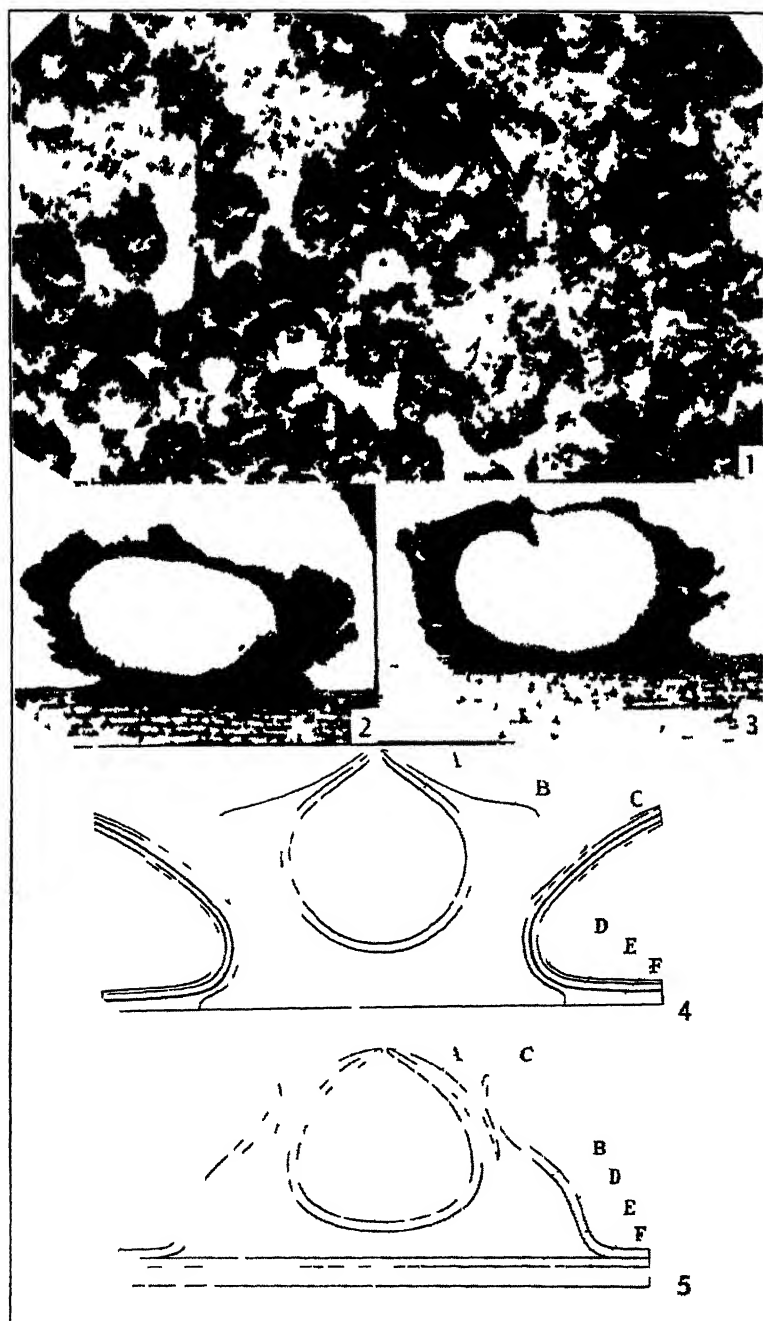
*nigricans*, *Venenarius Frostianus*, *Pholiota Johnsoniana*, *Pluteus cervinus*, and *Strobilomyces strobiluceus*.

Lunch was eaten by a spring beneath a shady canopy of red maple, white ash, black locust, persimmon, and dogwood branches, with thickets of blackberries close at hand and three June-apple trees in sight. We then swung southward to the fertile meadows of Staunton River and drove for a mile or more between hedgerows of trumpet creeper (*Tecoma radicans*), thickets of alder, and swamps filled with cattails. Near Altavista, about twenty-five miles from Lynchburg, we found another very attractive spring at the foot of a hill beneath beech and maple trees. Here I botanized while the watermelon was cooling and collected a number of fungi not previously seen on the trip, among them *Chanterel cinnabarinus*, *Hypomyces* on *Venenarius solitarius*, the dark form of *Venenarius phalloides*, *Vaginata vaginata*, *Tyromyces semipileatus*, and *Coltricia cinnamomea*.

From this point, we went to Lynch's Station, where I was born, then turned northward over a good road and reached Lynchburg just at dusk.

W. A. MURRILL





*ASTROCYSTIS MIRABILIS*

# MYCOLOGIA

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## THE GENUS ASTROCYSTIS

WILLIAM W. DIEHL

(WITH PLATE 19)

*Astrocystis mirabilis* B. & Br. (1: 123, fig. 36) was described in 1873 from material on dead culms of bamboo. It was the type of a genus to which no species have since been added. The erumpent condition of the perithecium coupled with the peculiar volva-like appearance at its base were regarded as sufficient cause for generic segregation; but from the figure (l.c.) and the lack of further explanation it is to be inferred that this *volva* is simply revolute host tissue.

Penzig and Saccardo (6: 7. pl. IVd. fig. 3) considered the general structure of the mature perithecium to be that of a *Rosellinia* but did not alter the nomenclatorial status of the species nor did they explain further the character of the ascocarp.

Von Höhnelt (4: 326-328) showed that in development up to maturity—he states “zur volligen reife”—the perithecium remains sub-epidermal. He did not regard it as a *Rosellinia* and referred the species, apparently solely upon this subepidermal condition, to *Anthostomella*, relegating *Astrocystis* to the position of a section in the genus. Von Höhnelt did not, however, discuss the nature of the perithecial wall which should have a bearing upon the generic position of the fungus. Previous to emergence the stromatic character of the perithecial wall is not prominent. In all specimens examined where the ascocarps were still immersed, the asci and spores, although definitely formed, were of

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much smaller dimensions than those considered mature; the spores were also light brown and translucent by comparison. There seems no reason for considering this immersed condition other than immature.

The position of young perithecia is extremely variable. Sections of some specimens show the structure to be seated just above the innermost layer of the hypodermis, *i.e.*, intrahypodermal; the hypodermis here is a well-defined tissue of three to four layers of sclerenchymatous cells. A portion of these cells is plainly replaced by the stroma, the perithecial base then appearing subhypodermal. In some specimens the perithecium is subcuticular, in others subepidermal. It is probable that the character of the tissues of individual host species may determine the position of perithecial development. The varying relations of the ascocarp to the host tissues in this species show the disadvantage of considering position as an important criterion in separating certain genera.

Sections of matured, erumpent perithecia *in situ* clearly show a stromatic wall extremely thickened except near the apex. This stromatic structure is usually, but not always, definitely split into irregular segments giving a characteristically asteroid, basal periphery or *pseudo-volva*. In the emergence of the perithecium the overlying host tissue is split in a definitely stellate manner, the segments becoming revolute and subtending the stromatic pseudo-volva as an additional stellate collar. This collar of host tissue, to which some stromatic fungus tissue usually adheres, is illustrated and referred to by Berkeley and Broome (*l.c.*) as the *volva*. The stellate splitting of the pseudovolva is less evident in the subcuticular than in the subepidermal or intrahypodermal perithecia. In all types of emergence, however, there is a definite exfoliation of stroma from the upper part of the perithecium leaving that area smooth or evenly granular.

The stromatic pseudo-volva of the perithecium may well be homologous to the sclerotic subicle frequently found in *Rosellinia* and in the Cucurbitariaceae. The fact that in early maturity the perithecium is similar to *Anthostomella* in form and position is merely suggestive of the possible phylogeny of the species. Since it is distinct from the conception of either *Rosellinia* or

*Anthostomella*, there is no valid reason for referring *Astrocystis* to the status of a subgenus or section of either. If stromatic characters are to be regarded as important criteria in distinguishing genera, *Astrocystis mirabilis* may best remain as the type of a distinct genus which has evident affinities among the Sphaeriaceae with *Anthostomella* and *Rosellinia* and among the Xylariaceae with *Hypoxylon*. Lindau (5: 411) has given *Astrocystis* a doubtful position in the Cucurbitariaceae, but it is so plainly allied with certain Sphaeriaceae that its disposition in the latter family seems desirable for the present.

It has not been possible to find among the species of *Anthostomella* growing on Bambuseae any which are definitely recognizable as cospecific with *Astrocystis mirabilis*. But there can be little doubt that *Rosellinia geasteroides* Ellis & Ev. (2: 415-416) and *R. Bambusae* P. Henn. (3: 256) are synonyms; the former is an intrahypodermal condition, the latter described as superficial. *Rosellinia Bambusae* has previously been considered synonymous by Rehm (7: 1940) and by Sydow (9: 486). Although Rehm (8: 2939) has relegated to synonymy with this species both *Auerswaldia Arengae* Rac. and *Anthostomella discophora* Syd., the stromatic characters of neither seem sufficiently in agreement with it to justify such disposition. Through the kindness of Dr. A. D. Cotton and Miss E. M. Wakefield of the Royal Botanic Gardens, Kew, it has been possible to obtain type material for comparison with the other specimens examined.

#### SYSTEMATIC ACCOUNT

*Astrocystis* B. & Br., Jour. Linn. Soc. 14: 123. 1873.

Type species, *Astrocystis mirabilis* B. & Br.

Perithecia separate, rarely connivent, scattered to cespitose, subsuperficial to intrahypodermal and erumpent, subspherical, definitely flattened at the base, characterized when mature by a stromatic development of the outer wall and base, carbonous, rigid, apically ostiolate; asci cylindrical to clavate, 8-spored; ascospores simple, brown, walls smooth; paraphyses present.

Probably most closely related to *Rosellinia* and referred to the Sphaeriaceae, but in stromatic structure suggestive of the Xylariaceae.



*Astrocystis mirabilis* B. & Br., Jour. Linn. Soc. 14: 123. 1873.

*Rosellinia geasteroides* Ell. & Ev., Proc. Acad. Nat. Sci. Phila. 1895: 415-416. 1896.

*Rosellinia Bambusae* P. Henn., Hedwigia 47: 256. 1908.

*Anthostomella mirabilis* (B. & Br.) v. Höhn., Sitz. Akad. Wiss. Wien 118<sup>1</sup>: 326-328. 1909.

ILLUSTRATIONS: B. & Br., Jour. Linn. Soc. 14: fig. 36; Penz. & Sacc., Ic. Fung. Javan. pl. IVa. fig. 3.

Perithecia separate, rarely connivent, infrequent to cespitose, subsuperficial or immersed (subcuticular, subepidermal, or intrahypodermal), becoming erumpent and subspherical, 300-800  $\mu$  in diameter, in emergence usually splitting the overlying matrix in a stellate manner; outer perithecial wall thin toward the apex, thickened equatorially and toward the base as a pseudoparenchymatous, carbonous stroma; in development the stroma exfoliating tangentially in the region of the ostiole leaving the upper perithecial surface finely granular or smooth; exfoliated stroma partly attached to stellate segments of the ruptured matrix; the thickened stromatic outer wall of the perithecium variable in dimension and appearance but extending as a *pseudovolva* which is frequently ruptured radially with a resultant stellate periphery; ostiole papillate; perithecial cavity subspherical, reaching 600  $\mu$  in diameter; asci arising chiefly from the base of the perithecial cavity, cylindrical-clavate to cylindrical, sessile, thin walled, evanescent, 60-100  $\times$  6-13  $\mu$  (sec. Penz. & Sacc. 120-130  $\times$  6-7  $\mu$ ), with 8 spores uniseriately or irregularly arranged; ascospores acuminate or rounded, elliptical, narrow to broad, light brown becoming dark brown and subopaque, when mature 10-21  $\times$  4-12  $\mu$ , chiefly 11-13  $\times$  5-7  $\mu$ , walls thin, smooth, brittle; paraphyses flexuous, exceeding the asci in length, nearly 1  $\mu$  in diameter, gelatinizing and early evanescent.

DISTRIBUTION: Apparently cosmopolitan in tropical and subtropical regions upon Bambuseae.

#### SPECIMENS EXAMINED:

Ceylon: Type material (*Thwaites No. 785*), ex. herb. Roy. Bot. Gard. Kew.

Louisiana: 1895—on *Arundinaria* sp. A. B. Langlois 2404. Type coll. of *Rosellinia geasteroides*.

1895—on *Arundinaria* sp. A. B. Langlois—Ell. & Ev., N. Am. Fungi 3315 as *R. geasteroides*.

1896—on *Arundinaria* sp. A. B. Langlois—Path. Coll. 6406.

Philippine Islands: 1912—on *Bambusaceae*—P. W. Graff.  
Sydow: F. exot. exs. 126 as *R. Bambusae*.

1913—on *Gigantochloa Scribneriana*, C. F. Baker: F.  
Malayana 5 Suppl. 1 as *Anthostomella mirabilis*, det. Rehm.

1913—on *Bambusa vulgaris*, C. F. Baker: F. Malayana 5 as  
*A. mirabilis*, det. Rehm.

1914—on *Schizostachyum* sp. C. F. Baker: F. Malayana 110  
as *A. mirabilis* f. *Schizostachyi* Rehm, det. Rehm.

1915—on *Schizostachyum* sp. C. F. Baker: F. Malayana 5  
suppl. 2 as *Astrocystis mirabilis*, det. Sydow.

1913—E. D. Merrill, Bu. Sci. 9111.

1914—on *Schizostachyum* sp. E. D. Merrill, Bu. Sci. 9712.

1912—on *Schizostachyum* sp. Bu. Sci. 16983. M. Ramos.

1915—on *Bambusa*, R. C. McGregor, Bu. Sci. 23207.

1912—on *Bambusa*, P. W. Graff, Bu. Sci. 19007, det. Sydow  
—in U. S. Nat. Herb.

1906—E. D. Merrill, Bu. Sci. 5030. Type coll. of *Rosellinia*  
*Bambusae* in U. S. Nat. Herb.

Java: 1908—on *Bambusa* sp. v. Höhncl. Rehm: Ascomycetes  
1859 as *Anthostomella mirabilis*.

Except where noted otherwise, all the specimens cited above  
are in the Pathological Collections B. P. I.

BUREAU OF PLANT INDUSTRY,  
WASHINGTON, D. C.

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8. Rehm, H. Ascomycetes philippinenses VIII. Elmer, Leaf. Philip. Bot. 6: 2935-2961. 1916.
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## EXPLANATION OF PLATE 19

Photographs: fig. 1 by Mr. E. L. Crandall and figs. 2, 3 by Mr. M. L. S. Foubert of the U. S. Department of Agriculture.

Fig. 1. Perithecia  $\times 20$  from type material of *Astrocystis mirabilis*.

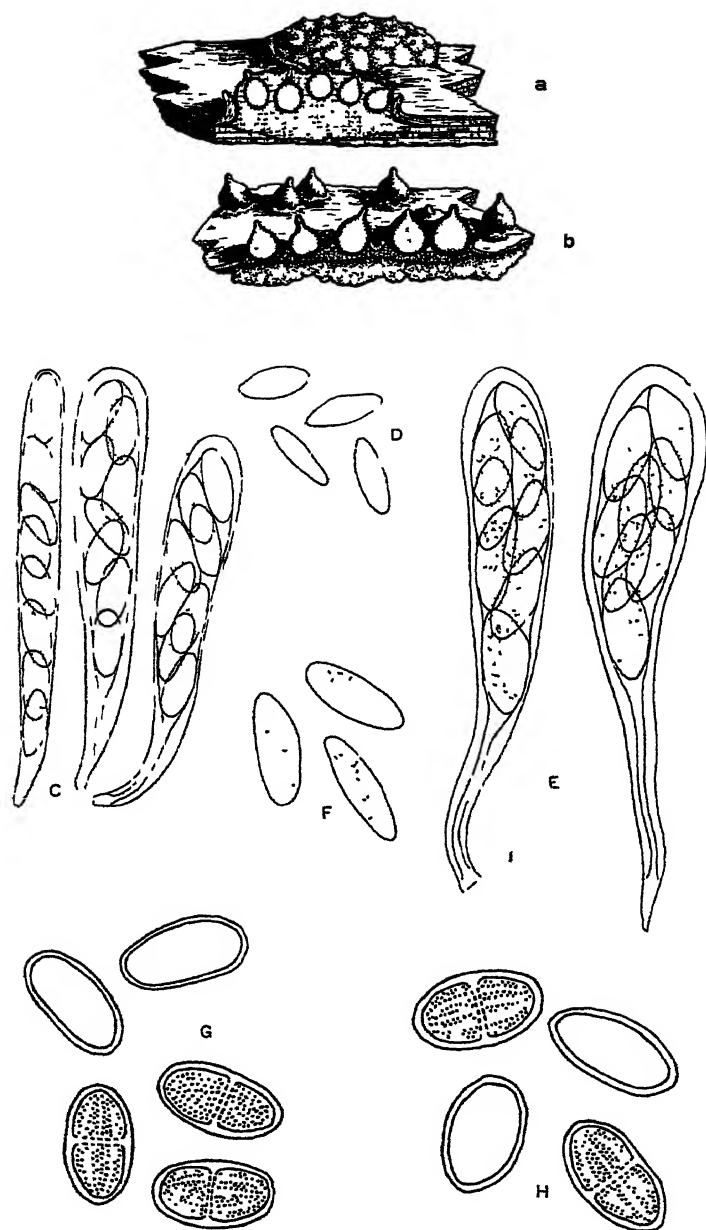
Fig. 2. Perithecium in longitudinal section (tangential)  $\times 60$ ; material from A. B. Langlois, Path. Coll. 6406.

Fig. 3. Perithecium in longitudinal section (through the region of the ostiole)  $\times 60$ , material same as of fig. 2.

Fig. 4. Diagrammatic drawing of longitudinal section of intrahypodermal perithecium to show interrelation of fungous and host tissues: *A*, Fertile inner wall of perithecium; *B*, outer stromatic wall (pseudo-volva) of perithecium; *C*, fragments of stroma adherent to host tissue; *D*, cuticle; *E*, epidermis; *F*, hypodermis.

Fig. 5. Diagrammatic drawing of longitudinal section of subcuticular perithecium, designation as in fig. 4.





PHYSALOSPORA AND BOTRYOSPHERA

# THE LIFE HISTORY AND RELATIONSHIPS OF DIPLODIA GOSSYPINA

NEIL E. STEFENS

(WITH PLATE 20)

In the course of a study of those species of *Botryosphaeria* and *Physalospora* which cause such well known diseases as currant cane-blight, black rot of apples and stem-end rot of citrus fruits (10, 11, 12, 13) much information has been obtained about the closely related *Diplodia gossypina* found on cotton and other plants in the southern states. The importance of *Diplodia gossypina* Cooke as a cause of boll rot of cotton (*Gossypium hirsutum*) has been pointed out by Edgerton (3) who published a careful description of the disease and of the pycnidial stage of the fungus. Edgerton also described a somewhat similar rot of cotton bolls caused by a species of *Botryosphaeria* which he referred provisionally to *B. fuliginosa* (M. & N.) E. & E. (2).

Continued collecting and study of the species of *Botryosphaeria* and *Physalospora* have shown that the perfect stage of *D. gossypina* is a *Physalospora* closely related to *P. malorum*, and that this fungus apparently is not confined to cotton but occurs on several other hosts in the southeastern United States. The evidence on these points is summarized in the present paper. There is also included a brief comparison of the genera *Physalospora* and *Botryosphaeria* with special reference to the species known to occur on cotton. The synonymy of the names *Diplodia gossypina* Cooke and *Botryosphaeria fuliginosa* (M. & N.) E. & E. is discussed only so far as is necessary to fix their status with reference to the fungi considered in this paper.

## DIPLODIA GOSSYPINA COOKE

*Diplodia gossypina* was described by Cooke (1) in 1879 as follows:

*Diplodia gossypina* Cooke. Gregaria, erumpens. Peritheciis sub-conicis, atris, subtus appianatis, fibrosis. Sporis ellipticis, olivaceo-brunneis, .022 x .012 mm.

On old capsules of *Gossypium*. Bombay (India). Washington, U. S. A. (Mr. T. Taylor).

This citation of specimens would suggest that material from two localities was examined when the description was prepared but in Cooke's herbarium at Kew, Doctor Shear was able to find only a single specimen under the name *D. gossypina*. This is labeled "*Diplodia gossypina* Cooke, Washington, U. S., T. Taylor, December, 1878." Spores from this specimen measure 20-27 x 10-15  $\mu$ , mostly 23-25 x 12-13  $\mu$ , and agree very well in size and appearance with Edgerton's description of pycnospores of the cotton boll rot *Diplodia* and with the spores which have developed in pure culture from single ascospores. Edgerton (3) suggests that the *Diplodia* on cotton may be the same as that found on other hosts, and that it may have been described under some other name previous to 1879. It is apparent, however, that the fungus with which we are dealing is identical with that described by Cooke as *D. gossypina* and as this name has become established by the use of Edgerton and others, it will be employed in this paper.

The fungus described by Ellis and Bartholomew (5) from cotton stems as *Botryodiplodia Gossypii* is apparently identical with *Diplodia gossypina*. Material of this species was distributed as Fungi Columbiani No. 1510. Under this number in the set examined by the writer there are two specimens, one of which is apparently *Diplodia gossypina* and the other one contains a *Botryosphaeria* apparently identical with that found on cotton and other hosts in the eastern United States and which has been referred to as *Botryosphaeria Ribis*, in the earlier papers (10, 11).

#### BOTRYOSPHERA FULIGINOSA (M. & N.) E. & E.

As already noted, Edgerton (2) provisionally referred the *Botryosphaeria* which he found on cotton to *B. fuliginosa* (M. & N.) E. & E. As Edgerton notes, Shear (9) had in 1909 called attention to the fact that *B. fuliginosa* was among the names applied in America to the grape fungus which he calls *Melanops Quercuum* (Schw.) Rehm *forma Vitis* Sacc., the pycnidial stage of which he had produced in pure culture from single ascospores and found to agree in all morphological characters with *Sphaeropsis malorum* Peck.

Apparently neither Shear nor Edgerton intended to give the impression that the fungi they were discussing were identical with *Botryosphaeria fuliginosa*, as the name is used by Ellis and Everhart (6), but merely to indicate that the name *B. fuliginosa* was one which had been used in referring to fungi similar to those with which they were dealing. This is undoubtedly true, since Ellis and Everhart, as is evident from their description and figures of *B. fuliginosa*, included under this name representatives of both *Botryosphaeria* and *Physalospora* as these genera are now understood. The reasons for the interpretation of this species made by them are somewhat fully given by Ellis (4) in his paper published in 1879, "On the Variability of *Sphaeria Quercuum*, Schw." (10, 11).

Ellis cites a number of species which he considers synonymous with *Sphaeria Quercuum* Schw. and says (4, p. 68):

"In all these different forms the character of the fructification is the same, or at most there is only a slight variation in the size of the asci and sporidia, so that from a microscopical examination of the fruit alone it would be impossible to say to which of the above species any particular specimen should be referred. This similarity will be readily seen on examining the figures in *Grevillea* illustrating the species cited. All have the same broad clavate, obtuse, stipitate asci which are often subject to a kind of deformity, being bent almost double. The paraphyses are simple, or sparingly branched, of a gelatinous nature, and, like the asci, soon dissolved. . . ."

"From an examination of the above notes it will be seen that, disregarding the somewhat variable ostiola, the various forms above noted differ from each other only in the fact that in some the perithecia are confluent and united in a partial stroma, while in others they are scattered and without any distinct stroma. The only question then is whether this variation alone is sufficient to constitute a specific difference" (p. 69).

Ellis, of course, did not take into consideration the pycnidial stages of the fungi he was discussing. He had, in fact, almost no information as to their life histories, and it is in the life histories of these fungi that their most conspicuous differences are found. The difference which Ellis notes in the arrangement of the perithecia would not *alone* appear "sufficient to constitute a specific difference" but this difference proves to be correlated with a



marked difference in the life histories of the organisms and thus becomes of real significance.

As will be pointed out below the perfect stages of these two genera are very similar in many respects, and the conclusion as to their relationship reached by Ellis is that which any competent mycologist might well have reached after a study based only on the morphological characters of the fungi unassisted by pure culture studies. The numerous species of these genera which have been described have been based almost wholly on their host relations and as Ellis and Everhart remark (6, p. 547), "Without knowing the host, it would be impossible to separate them." The distinctions which it is now possible to make between the perfect stages of these two fungi were discovered and it may fairly be assumed were discoverable only after continued study of the life histories and cultural characters of the species of these two genera from different hosts.

The species of these two genera resemble each other in the general appearance of their fruiting bodies on many hosts. The contents of the perithecia in both genera are pure white (see pl. 20), a character which is very useful in collecting. The ascospores are very similar in shape, as may be seen from Table III, in which are tabulated the ratios of length to width of 802 ascospores of *Botryosphaeria Ribis*, on seventeen hosts, and 1213 ascospores of *Physalospora malorum* from twenty-two hosts.

Moreover, while the ascospores differ in size they overlap somewhat (9, 10), that is the largest ascospores of *B. Ribis* are equal in size to the smaller ones of *P. malorum*. The separation of these species by morphological studies alone was rendered particularly difficult by the fact that certain species of both genera occur on the same host. Indeed, mature perithecia of species of the two genera are often found intermingled within a square centimeter of host bark.

The differences in the two genera as exemplified by *Botryosphaeria Ribis* and *Physalospora malorum* have been pointed out in two earlier papers (10, 11). They may be briefly summarized as follows: The most important character, as was suggested above, is the difference in their life histories. *Botryosphaeria* has a *Dothiorella* as its pycnidial stage, and *Physalospora* a

TABLES I TO III  
ASCOSPORE MEASUREMENTS

Table I. Lengths	Total no. of spores	Number of spores having a given length in microns														
		18	19	20	21	22	23	24	25	26	27	28	29	30	31	32
<i>Physalospora malarum</i> on 23 hosts (see 11, p. 99) . . . . .	1213															
<i>Physalospora gossypina</i> on cotton . . . . .	100	1		4		9	23	40	57	75	161	148	105	169	90	123
<i>Physalospora gossypina</i> on 5 hosts listed on p. 197 . . . . .	687							3	17	11	28	26	27	74	43	115

Table II. Widths	Total no. of spores	Number of spores having a given width in microns											
		6	7	8	9	10	11	12	13	14	15	16	17
<i>Physalospora malarum</i> on 23 hosts (see 11, p. 99) . . . . .	1213	1	34	75	173	331	281	207	78	27	4	2	
<i>Physalospora gossypina</i> on cotton . . . . .	100			3	17	37	25	12	5	1			
<i>Physalospora gossypina</i> on 5 hosts listed on p. 197 . . . . .	687		1	7	11	53	90	182	154	108	67	10	1

Table III. Ratios of length to width	Total no. of spores	Number of spores having a given ratio of length to width				
		1.5	2	2.5	3	3.5
<i>Botryosphacria Ribis</i> on 17 hosts (see 11, p. 99) . . . . .	802	15	141	280	258	76
<i>Physalospora malarum</i> on 23 hosts (see 11, p. 99) . . . . .	1213	1	112	461	126	150
<i>Physalospora gossypina</i> on cotton . . . . .	100		4	21	47	14
<i>Physalospora gossypina</i> on 5 hosts listed on p. 197 . . . . .	687		88	397	172	26

*Sphaeropsis*. Ascospores of *B. Ribis* measure from  $13-28 \times 4-10 \mu$ , mostly  $17-22 \times 6-8$ , while those of *P. malorum* measure  $18-40 \times 7-14 \mu$ , mostly  $30-34 \times 8-10$ . There is also a characteristic difference in the germination of the ascospores of the two species in agar plates at temperatures from  $12^{\circ}$  to  $15^{\circ}$  C. Under these conditions ascospores of *B. Ribis* usually develop two short, branched germ tubes, while those of *P. malorum* usually develop a single germ tube which remains unbranched until it reaches a length which is fifty or more times the length of the spore. Perithecia of *B. Ribis* average about  $165 \times 130 \mu$  in size, perithecia of *P. malorum* average about  $245 \times 210 \mu$ . Several perithecia of *B. Ribis* usually occur in a single stroma and even where a single perithecium occurs there is usually a noticeable amount of stromatic tissue associated with it. Perithecia of *P. malorum*, on the other hand, usually occur singly and with little associated stromatic tissue.

The differences in size and in the appearance of the perithecia of the two fungi on a single host are clearly illustrated by the figures of the two forms on oak given by Ellis and Everhart. The figures here reproduced as Figures A and B of Plate 20 are from a photograph made by Mr. J. F. Brewer of the original drawings by F. W. Anderson of Plate 36 of Ellis and Everhart, now the property of Dr. C. L. Shear. The accuracy of these drawings is attested by the fact that even though the authors believed they were dealing with a single species the characteristic differences in the size and arrangement of the perithecia are fully brought out.

Before our studies of this group of fungi are concluded it is hoped to make a critical comparison of type and authentic material of many of the species which have been referred to the various closely allied genera, including most of the species listed by Ellis and Everhart as synonyms of *Botryosphaeria fuliginosa*. This cannot be done at present. Examination of the figures here reproduced and of the spore measurements given by Ellis and Everhart (6),  $18-38 \times 8-15 \mu$ , can leave no doubt that they included under this name representatives of both *Botryosphaeria* and *Physalospora* as these genera are now understood.

## THE BOTRYOSPHERA ON COTTON

In describing the *Botryosphaeria* on cotton which he referred tentatively to *B. fuliginosa*, Edgerton (2) pointed out that the pycnidial stage belonged to the form genus *Macrophoma* which he used as equivalent to *Dothiorella* as defined by Shear, Stevens, and Wilcox (10) and that this fungus was specifically distinct from *Diplodia gossypina*. With his conclusion the observations of the present writer agree. It is then no longer desirable to use the name *B. fuliginosa*, which was never a valid name for any of these fungi, in connection with this fungus which is apparently identical with that found on numerous other hosts in the eastern United States and which has been clearly defined and called (11) *Botryosphaeria Ribis* G. & D. Whether both the forms of *B. Ribis* which have been recognized are found on cotton is not yet certain. Since, however, *B. Ribis* has been found well distributed over the southeastern United States and *B. Ribis chromogena* has been found on apples as far south as Fort Valley, Ga., it is probable that both forms will be found on cotton.

## THE PHYSALOSPORA ON COTTON AND OTHER HOSTS IN THE SOUTHERN STATES

The pycnidial stage of the fungus here called *Diplodia gossypina* is very common on cotton in the southeastern United States. No reference to its connection with a perithecial stage can, however, be found in available literature. In March, 1924, at Madison, Fla., the writer collected on cotton stems a fungus very similar to *Physalospora malorum* as described under the name of *P. Cydoniae* by Hesler (8) and later as *P. malorum* (10), but having slightly larger ascospores. A number of single ascospore cultures were made from this material, in all of which there developed pycnosporos identical with *D. gossypina*.

Mature perithecia of a fungus, which is apparently identical with the *Physalospora* on cotton, were found during the same collecting trip on the following hosts in the southern states: *Hicoria* (four localities), *Ilex*, *Liquidambar*, *Quercus* (twenty-three localities) and *Vitis*. Single ascospore cultures were made from each separate lot of material on all of these hosts and in all

cases the pycnospores produced were identical with *D. gossypina*. While the size of the sporocarps of this fungus varies as in *P. malorum* (12) with the nature and thickness of the host bark, they agree so closely in all other respects, both in the perithecial and pycnidial stages, that the conclusion that they belong to the same species seems unavoidable. The similarity in size of the ascospores from the various hosts is shown in Tables I to III. The relative size of the ascospores of this fungus and that of *Botryosphaeria Ribis*, which is also found on cotton and other hosts in the southern states, may be seen in Plate 20, Figures C, D, E, and F, also (11, Pl. 9, Figs. A, F, K).

It is highly probable that the perfect stage of this fungus already has been described from some host in the southern states. The writer has, however, so far been unable to establish this fact and is thus under the necessity of designating it as *Physalospora gossypina*.

The only characters which the writer has thus far found which will serve to distinguish the perfect stage of this fungus from that of *P. malorum* is a slight difference in the size of the perithecia and the difference in the size of the ascospores. Perithecia of *P. gossypina* usually average about  $294 \times 245 \mu$  in diameter, while perithecia of *P. malorum* average about  $245 \times 210 \mu$  in diameter. As will be observed from Tables I and II, the ascospores of the cotton fungus measure  $24-42 \times 7-17 \mu$ , mostly  $30-35 \times 11-14$ . Those of *P. malorum*, on the other hand, measure  $18-40 \times 6-16 \mu$ , mostly  $27-32 \times 9-12$ . The spores of the two fungi are so similar in shape that one would hesitate to separate them on ascospore characters alone.

The pycnospores of these two fungi are, however, readily distinguished by the difference in their size and shape, in the color of the mature spores, and the frequency with which septate spores are found. While the pycnospores of the two fungi are much alike in length, *P. malorum* measuring  $17-32 \mu$  and *D. gossypina*  $17-35 \mu$ , there is more difference in their widths, pycnospores of *P. malorum* measuring  $7-15 \mu$ , mostly 12, while those of the cotton fungus measure  $9-23 \mu$ , mostly 14. This difference in width is of course reflected in their shape as expressed in their ratio of length to width, the most frequent ratio in pycnospores of *P.*

*malorum* being  $2.5\ \mu$ , while in *D. gossypina* it is  $2\ \mu$ . Pycnospores of *P. malorum* almost always become colored in the pycnidium, indeed full-sized hyaline spores are seldom found. The spores of *D. gossypina*, on the other hand, rarely become colored until they are ready to be discharged from the pycnidium and numerous hyaline spores may be found in almost any section of a mature pycnidium.

Colored spores of *D. gossypina*, on the other hand, are usually septate, whereas septate spores are very rare in *S. malorum*. The light brown spore wall of *S. malorum* is smooth or very finely punctate, while in the somewhat darker spore wall of *D. gossypina* there may often be detected longitudinal striations similar to those figured by Evans (7) in *D. natalensis*.

It will be noted that these are exactly the characters used to distinguish *P. malorum* (13) from the fungus common on citrus in Florida and Cuba and generally known as *Diplodia natalensis*. The pycnidial stages of *D. gossypina* and *D. natalensis* are, in fact, so far as the writer has yet discovered, indistinguishable morphologically. As explained in an earlier paper (13), material of the perithecial stage of *D. natalensis* has not yet been obtained in sufficient quantity to make a careful study and comparison possible. Until such a comparison is made, it will probably be wiser to consider them as separate species and retain the names now in use. One conspicuous physiological character serves to distinguish the citrus stem-end rot *Diplodia* in culture from the fungus found on cotton and other hosts. This is the temperature relation of the two fungi. As noted in an earlier paper, *D. natalensis* (13) will grow fairly well on agar in plates at  $36^{\circ}$  to  $37^{\circ}$  C. The cotton fungus, on the other hand, will not grow at these temperatures and grows only very slowly at  $31^{\circ}$  to  $32^{\circ}$  C. The above statements must not be interpreted as meaning that the high temperature *Diplodia* never occurs on oak or cotton, or that the low temperature *Diplodia* does not occur on *Citrus* or even as a cause of stem-end rot of citrus fruits. It is, on the contrary, probable that each will occasionally be found on the host habitually occupied by the other. There is, as yet, no evidence whatever that the *Diplodia* species common in the southeastern United States are limited to certain hosts. It is

not possible at this time to review the rather extensive literature relating to the *Diplodia* species known to cause diseases of cultivated plants. It may be well to state, however, that the writer has not yet met any investigator who regarded the species as limited to particular hosts. The prevalent opinion, on the other hand, among those who have studied these *Diplodia* diseases in the field is that the common species of *Diplodia* pass readily from one host to another.

#### SUMMARY

The perfect stage of *Diplodia gossypina* proves to be a *Physalospora* closely related to *P. malorum*.

The perfect stage of this fungus, which is provisionally called *Physalospora gossypina*, is distinguished from *P. malorum* by having slightly larger perithecia and ascospores.

The pycnospores of the two fungi are easily distinguished by their size, color, and the relative number of septate spores.

*Diplodia gossypina* cannot be distinguished at present from *Diplodia natalensis* on morphological grounds, but *D. natalensis* is able to grow at higher temperatures than *D. gossypina*.

*Botryosphaeria fuliginosa*, as used by Ellis and Everhart, includes species belonging to both the genera *Botryosphaeria* and *Physalospora* as now understood. It was apparently never a valid name for any of these fungi. The name *Botryosphaeria Ribis* G. & D. is now applied to the *Botryosphaeria* on cotton.

BUREAU OF PLANT INDUSTRY,  
WASHINGTON, D. C.

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## EXPLANATION OF PLATE 20

- A. Perithecial stroma of *Botryosphaeria* sp. (× 20.) Reproduced from a photograph by James F. Brewer of the original drawing of figure 2, plate 36, in Ellis & Everhart's "North American Fungi," in which it is designated as *Botryosphaeria fuliginosa* (M. & N.), somewhat enlarged on decaying limb of *Quercus coccinea*.
- B. Mature perithecia of *Physalospora* sp. (× 20.) Reproduced as was figure A from figure I, plate 36, in Ellis & Everhart's "North American Fungi," where it is designated as *Botryosphaeria fuliginosa* (M. & N.), somewhat enlarged on an oak gall.
- C. Asci of *Botryosphaeria Ribis* from *Aesculus*, Washington, D. C. (× 560.)
- D. Ascospores from same material as C. (× 560.)
- E. Asci of *Physalospora gossypina* from *Quercus*, Eden, Miss. (× 560.)
- F. Ascospores from the same material as E. (× 560.)
- G. Pycnosporos of *Diplodia gossypina* Cooke from his type material. (× 615.)
- H. Pycnosporos of *Physalospora gossypina*, grown in pure culture from single ascospores. (× 615.)



## SMUTS AND RUSTS OF UTAH—V<sup>1</sup>

A. O. GARRETT

### USTILAGINALES

- 29\*. *TILLETIA FOETENS* (B. & C.) Trel. Par. Fungi Wisc. 35. 1884.

In ovaries of *Triticum vulgare* Vill. Collected by Miss Clara Anderson, at Murray, Salt Lake Co., April 1, 1924.

### UREDINALES

8. *MELAMPSORA CONFLUENS* (Pers.) Jackson.

*Caeoma confluens* (Pers.) Schröt.

On *Ribes aureum* Pursh: I, Collected by George A. Root in Ogden Canyon, Weber County, June 17, 1921. This is the first collection of *Melampsora confluens* on this host.

On *Salix Scouleriana* Barratt: 3009a, II, August 26, 1921, Brighton Resort, Big Cottonwood Canyon, Salt Lake Co.; 3027, August 31, 1921, Spring Hollow, Logan Canyon, Cache Co.

9. *GYMNOSPORANGIUM NELSONI* Arthur. I, III.

On leaves of *Amelanchier polycarpa* Greene: 2718a, I, Aug. 3, 1920, Beaver Canyon, Beaver Co.; 3017, I, Aug. 31, 1921, Spring Hollow, Logan Canyon.

On *Juniperus scopulorum* Sarg.: 2686a, III, July 27, 1920, Coal Creek branch of Cedar Canyon, Cache Co.

The *Gymnosporangium* mentioned in the discussion of *Gymnosporangium gracile* (No. 152 in "Smuts and Rusts of Utah") belongs here.

<sup>1</sup> The previous papers of "Smuts and Rusts of Utah" were published in MYCOLOGIA as follows: I, 2: 265-304, Nov., 1910; II, 6: 240-258, Sept., 1914; III, 11: 202-215, July, 1919; IV, 13: 101-110, March, 1921.

Numbers followed with the asterisk (\*) are those of species not included in any of the four preceding lists.

## 11. MELAMPSORA BIGELOWII Thüm. II.

On *Salix subcoerulea* Piper: 3009, Aug. 20, 1921, Fish Lake Resort, Sevier Co. Rust determined by Dr. J. C. Arthur; host by Dr. P. A. Rydberg.

## 15. MELAMPSORELLA ELATINA (Alb. &amp; Schw.) Arthur. I.

*Peridermium elatinum* (Alb. & Schw.) Schw. & Kze.

*Melampsorella cerastii* Schröt.

On *Abies concolor* (Gord.) Parry: 3114, I, July 12, 1924, Nature's Icebox Spring, Community Flat, Mt. Timpanogos, Utah Co.

## 21. PHRAGMIDIUM MONTIVAGUM Arthur. II.

On *Rosa neomexicana* Cockerell: 3026, Aug. 31, 1921, Spring Hollow, Logan Canyon, Cache Co.

On *Rosa pyrifera* Rydb.: 3007, Aug. 20, 1921, Fish Lake Resort, Sevier Co.

## 22. PUCCINIA ABSINTHII DC. II.

On *Artemisia aromatica* A. Nels.: 2995, Aug. 12, 1921, Marysvale, Piute Co.

On *Artemisia tridentata* Nutt.: Spring Hollow, Logan Canyon, Cache Co.

On *Sphaeromeria diversifolia* (D. C. Eaton) Rydb.: 3011, Aug. 27, 1921, Pharaoh's Glen, Parley's Canyon, Salt Lake Co. This is the first collection of this rust on this host.

## 45. PUCCINIA DOUGLASII Ellis &amp; Ev.

On *Phlox canescens* T. & G.: 2606, June 25, 1920, Manti, San Pete Co.

## 55. PUCCINIA GRAMINIS Pers.

On *Elymus glaucus* Buckley: 2691, III, Aug. 27, 1921, Coal Creek Canyon near Cedar City, Iron Co. Weathered material.

On stems and leaves of *Phleum pratense* L.: 3063, Sept. 16, 1922, west side of Weber River, near bridge at Wanship, Summit Co. Not before reported from Utah on this host.

Arthur (N. Am. Flora 7: 296. 1920) mentions a collection of this rust made in Utah on *Agropyron caninum* (L.) Beauv.

## 69. PUCCINIA JONESII Peck. I.

On the leaves of *Aulospermum longipes* (Wats.) C. & R.: 3109, I, collected by Miss La Rue Larsen, May 27, 1924, Salt Lake City. This is the first collection of *Puccinia Jonesii* on this host.

## 80. PUCCINIA MUTABILIS Ellis &amp; Gall. I.

Aecia on a single leaf of *Allium Diehlii* M. E. Jones, collected in Parley's Canyon, Salt Lake Co., are tentatively referred to this species.

## 81. PUCCINIA PIMPINELLAE (Str.) Mart.

*P. Osmorrhizae* (Peck) Cooke & Peck.

On *Glycosma occidentalis* Nutt.: 3021, III, Spring Hollow, Logan Canyon, Cache Co.

## 88. PUCCINIA EPIPHYLLA (L.) Wettst. II.

*Puccinia Poarum* Niels.

On *Catabrosa aquatica* (L.) Beauv.: 3004, Fish Lake Resort, Sevier Co.

## 96. PUCCINIA SHERARDIANA Körn. III.

On *Sphaeralcea coccinea* (Nutt.) Rydb.: 2983, August 10, 1921, Manti, San Pete Co.

## 105. PUCCINIA SUBNITENS Dietel. I.

On *Atriplex rosea* L.: 2802, May 14, 1921, Granger, Salt Lake Co.

On *Camelina microcarpa* Andrz.: 2799, May 14, 1921, Granger, Salt Lake Co.

On *Capsella Bursa-pastoris* Medic.: 2803, May 14, 1921, Granger, Salt Lake Co.

On *Erysimum repandum* L.: 2801, May 14, 1921, Granger, Salt Lake Co.

On *Lepidium simile* Heller: 2798, May 14, 1921, Granger, Salt Lake Co.

On *Hutchinsia procumbens* (L.) Dev.: 2794, May 14, 1921, Granger, Salt Lake Co.

On *Sophia intermedia* Rydb.: 2800, May 14, 1921, Granger, Salt Lake Co.

Arthur (N. Am. Flora 7: 306. 1920) records a collection of *P. subnitens* made in Utah on *Chenopodium pratericola* Rydb.

## 115. PUCCINIA TUBERCULANS Ellis &amp; Ev. III.

On *Chrysothamnus puberulus* (Eat.) Greene: 2605, June 26, 1920, Manti, San Pete Co.

On *Chrysothamnus marianus* Rydb.: 2990a, Aug. 10, 1921, Manti, San Pete Co.

## 116. PUCCINIA UNIVERSALIS Arthur. II, III.

On *Carex festivella* Mackenzie: 2745a, Brighton Resort, Big Cottonwood Canyon, Salt Lake Co.

On *Carex* sp.: 2634, II, July 15, 1920, Gogorza, Summit Co.

## 119. PUCCINIA VIOLAE (Schum.) DC.

On *Viola adunca* J. E. Smith: 3024, Spring Hollow, Logan Canyon, Cache Co.

## 123. PUCCINIASTRUM PUSTULATUM (Pers.) Dietel. II.

On *Epilobium americanum* Haussk.: 2988, Aug. 10, 1921, Manti, San Pete Co.; 3012, Aug. 27, 1921, Pharaoh's Glen, Parley's Canyon, Salt Lake Co.

## 131. UROMYCES INTRICATUS Cooke. II.

*U. Eriogoni* Ellis & Hark.

On *Eriogonum biumbellatum* Rydb.: 3001, Aug. 20, 1921, Fish Lake Resort, Sevier Co.

On *Eriogonum microthecum* Nutt.: 2646, July 17, 1920, Maple Canyon branch of Coal Creek Canyon, near Cedar City, Iron Co.

On *Eriogonum racemosum* Nutt.: 2674a, July 22, 1920, Zion National Park, Washington Co.

## 135. UROMYCES HETERODERMUS Syd. III.

On *Erythronium grandiflorum parviflorum* S. Wats.: 2587, May 16, 1920, City Creek Canyon, Salt Lake Co. Collected by Garrett & Posey.

## 137. UROMYCES FABAE (Pers.) De Bary.

On *Lathyrus utahensis* Jones: 2690, Maple Creek branch of Coal Creek Canyon, near Cedar City, Iron Co.

## 138. UROMYCES OCCIDENTALIS Dietl.

On *Lupinus* sp.: 2993, Aug. 12, 1921, Marysville, Piute Co.

## 148. COLEOSPORIUM RIBICOLA (C. &amp; E.) Arthur. II.

On *Ribes inebrians* Lindl.: 3002, Aug. 20, 1921, Fish Lake Resort, Sevier Co. All of the Utah collections of *Coleosporium ribicola* have been made on this host, heretofore designated in these notes as *R. cereum*.

## 150. CRONARTIUM PYRIFORME (Peck) Hedg. &amp; Long. II, III.

On *Comandra pallida* A. DC.: 3025, Aug. 31, 1921, Spring Hollow, Logan Canyon, Cache Co.

## 151. GYMNOSPORANGIUM CLAVARIAEFORME (Jacq.) DC. I.

On *Amelanchier florida* Lindl.: 3000, Aug. 20, 1921, Fish Lake Resort, Sevier Co. The specimens of *Amelanchier* were growing next to bushes of *Juniperus Siberica*. The rust on *Amelanchier* was abundant.

## 153. GYMNOSPORANGIUM INCONSPICUUM Kern. I.

On fruit of *Amelanchier prunifolia* Greene: 2692, July 22, 1920, Zion's National Park, Washington Co.

## 154. MELAMPSORA ALBERTENSIS Arthur. II.

On water-sprouts of *Populus tremuloides* Michx.: 3018, Aug. 31, 1921, Spring Hollow, Logan Canyon, Cache Co.

## 155. PHRAGMIDIUM OCCIDENTALE Arthur.

On *Rubus parviflorus* Nutt.: Aug. 31, 1921, Spring Hollow, Logan Canyon, Cache Co.

## 164. PUCCINIA GRINDELIAE Peck.

*P. Gutierreziae* Ellis & Ev.

On *Gutierrezia glomerella* Greene: 2682, July 23, 1920, Hurricane, Washington Co.; 2657, July 17, 1920, Maple Creek branch of Coal Creek Canyon, near Cedar City, Iron Co.

## 165. PUCCINIA GROSSULARIAE (Schum.) Lagerh.

On *Carex* sp.: 3013, Aug. 27, 1921, Pharaoh's Glen, Parley's Canyon, Salt Lake Co.

## 168. PUCCINIA OBLITERATA Arthur. I.

On *Aquilegia flavescens* Watson: 3113, July 12, 1924, glacial cirque above Aspen Grove, Mt. Timpanogos, Utah Co. This is

the first collection of this species in Utah on *A. flavescens*. Dr. Arthur now considers *Puccinia oblitterata* to be a form of *Puccinia Clematidis* (DC.) Lagerh.

176. PUCCINIA VARIOLANS Hark. III.

On *Tetradymia Nuttallii* T. & G.: 2990, Aug. 10, 1921, Manti, San Pete Co.

187. CRONARTIUM OCCIDENTALE Hedg., Bethel & Hunt. II, III.

On *Ribes aureum* Pursh: 2982, Aug. 10, 1921, Manti, San Pete Co.; 2991, Aug. 12, 1921, Marysvale, Piute Co.; 2996, Aug. 14, 1921, Panguitch, Garfield Co.; 2997, Aug. 16, 1921, Mt. Carmel, Kane Co.; 2998, Aug. 17, 1921, Richfield, Sevier Co. All of the above are new county records for the occurrence of this *Cronartium*.

188. GYMNOSPORANGIUM BETHELI Kern. I, III.

On leaves of *Crataegus rivularis* Nutt.: 3016, Aug. 31, 1921, Spring Hollow, Logan Canyon, Cache Co.

On *Juniperus scopulorum* Sarg.: 3020, Aug. 31, 1921, Spring Hollow, Logan Canyon, Cache Co.

189. GYMNOSPORANGIUM JUVENESCENS Kern.

On leaves of *Amelanchier florida* Lindl.: 3014, I, Aug. 27, 1921, above Pharaoh's Glen, Parley's Canyon, Salt Lake Co.

On leaves of *Amelanchier Jonesiana* C. K. Schneider: 2661a, I, July 19, 1920, Coal Creek Canyon near Cedar City, Iron Co.

On leaves of *Amelanchier polycarpa* Greene: 2645, I, July 17, 1920, Maple Creek branch of Coal Creek Canyon, near Cedar City, Iron Co.

On leaves of *Amelanchier utahensis* Koehne: 2643, I, July 16, 1920, Coal Creek Canyon near Cedar City, Iron Co.

All hosts of the above collections were determined by Dr. Rydberg and all rusts by Dr. Arthur.

214\* PUCCINIA CICUTAE Lasch. Klotzsch, Herb. Viv. Myc. 787. 1845.

On *Cicuta occidentalis* Greene. Collected by Wyatt W. Jones, Sept. 7, 1922, at Charleston, Wasatch Co. Not before reported from Utah.

- 215\* PUCCINIA POLYGONI-AMPHIBII Pers. Syn. Fung. 227. 1801.

On *Persicaria psycrophila* Greene: 3062, II, III, Sept. 16, 1922, west bank of Weber River, near bridge east of Wanship, Summit Co. Host determined by Dr. Rydberg.

On *Persicaria Hartwrightii* (A. Gray) Greene. Listed in N. Am. Flora (7: 381. 1920) as occurring in Utah on this host.

- 217\* PUCCINIA POLYGONI-VIVIPARI H. Dietr. P. Karst. Not. Faun. Fl. Fenn. (8: 21. 1869).

On *Bistorta bistortoides* (Pursh) Small (*Polygonum bistortoides* Pursh). Collected by H. F. Bergman in Logan Canyon, Cache Co., August 17, 1917.

- 218\* UROMYCES FALLENS (Desm.) Kern, Phytopathology 1: 6. 1911.

On *Trifolium pratense* L. Collected by Wyatt W. Jones at Provo, Utah Co., Oct. 23, 1918.

- 219\* UROMYCES RICKERIANUS Arthur, Bull. Torrey Club 29: 227. 1902.

On *Rumex pauciflorus* Nutt.: 2632, III, July 15, 1920, Gogorza, Summit Co.; 3035, I, same locality, June 15, 1922.

- 220\* UROMYCES SHEARIANUS Arthur, Bull. Torrey Club 46: 120. 1920.

On *Atriplex confertifolia* (Torr.) S. Wats. Listed in N. Am. Flora (7: 443. 1921) as occurring in Utah on this host.

- 221\* UROMYCES SILENES (Schlecht.) Fckl. Symb. Myc. 61. 1869.

On *Arenaria glabrescens* (Wats.) Howell: 2648, July 17, 1920, Maple Canyon branch of Coal Creek Canyon, near Cedar City, Iron Co.

- 222\* UROMYCES SUBSTRIATUS Sydow, Ann. Myc. 4: 30. 1906.

On *Lupinus* sp.: 3102, Oct. 6, 1923, East Canyon, Summit Co.; 3103, Oct. 6, 1923, Gogorza, Summit Co.; 3104, Oct. 6, 1923, 19½ miles up Parley's Canyon, Salt Lake Co. The rust was

very abundant, especially at the last-named location. A little observation should enable one to discover the aecial host. No plants of *Euphorbia robusta*, the alternate host of *Uromyces occidentalis*, are to be found anywhere near.

We are indebted to H. S. Jackson for determination of the rust.

223\* PUCCINIA CREPIDIS-MONTANAE Magnus; Ed. Fisch. Beitr. Krypt. Schweiz. 2<sup>2</sup>: 212. 1904.

Mentioned in N. Am. Fl. 7: 440. 1921, as occurring in Utah on *Crepis glauca* (Nutt.) T. & G.

EAST HIGH SCHOOL,  
SALT LAKE CITY, UTAH.



## UN NUEVO GENERO DE LAS HELVELLACEAS

C. SPEGAZZINI

### *Cudoniopsis* Speg. gen. nov.

*Char.* Helvellea, geoglossea, hyalospora; sclerotium superficial, irregulariter ellipsoideum, subcarnoso-lentum, extus viscosum olivaceum; ascomata plura discreta, sclerotio insititia, fusco-olivacea, stipite simplice terete gracili rigidulo subcorneo glabro laevi divaricato recto v. arcuato-adscedente fulta, pileolo apicali primo subhemisphaerico, margine involuto, serius digitaliformi v. anguste campanulato, crassiuscule membranaceo coronata; asci superficiem totam pileoli externam efformantes, lineares, apice poro pertusi, paraphysibus filiformibus apice non incrassatis rectisque aequilongis obvallati, octospori; sporae e globoso ellipsoideae, monostichae, laeves, fumoso-olivascens.

### *Cudoniopsis pusilla* Speg. sp. nov.

*Diag.* Characteres generis; sclerotia pro ratione majuscula, extus colliculoso-viscosa; ascomata pusilla sub rore viscosa sclerotio obscuriora; asci cylindracei apice obtusi crassiuscule tunicati, deorsum breviuscule cuneato-pedicellati; sporae ellipsoideae parvae.

*Hab.* Sobre ramas vivas, de dos o tres años de edad, de *Eugenia proba* Brg. en los alrededores de Puerto Blest, Neuquen, Agst. 1921.

*Obs.* Este curioso honguillo es el primer tipo biófilo y parasto que se viene a conocer entre las Helvellaceas, pues todas las demas conocidas hasta ahora resultan saprófilas o geófilas. Cuando coleccioné este micromiceta, creí que fuera parasto de las semillas de alguna Lorantacea o que se tratara de un organismo coprófilo sobre excrementos de alguna ave; recién al estudiarlo me dí cuenta de que el cuerpo maciso sobre el cual aparecian los ascomas era un esclerocio; este tiene forma elipsoide bastante irregular (5-6 mm. lng. x 2.5-3 mm. lat. et alt.) completamente superficial sobre la corteza del huesped, al cual adhiere por un escaso micelio penetrante endógeno y por la viscosidad de que va revestido; su superficie es levemente undulada lisa lampiña de

color olivaceo mas o menos subido, cuando húmedo cubierto de una capa mucilagínosa viscosa de la misma coloración; su parte interna es compacta de tinte verde sucio, formadas por cortas hifas ( $5-10\ \mu$  diám.) fumosas muy enmarañadas de paredes gruesa y luz interna reducida; los ascomas mas o menos numerosos ( $3-10\ \mu$ ) crean generalmente en la parte basal del esclerocio,

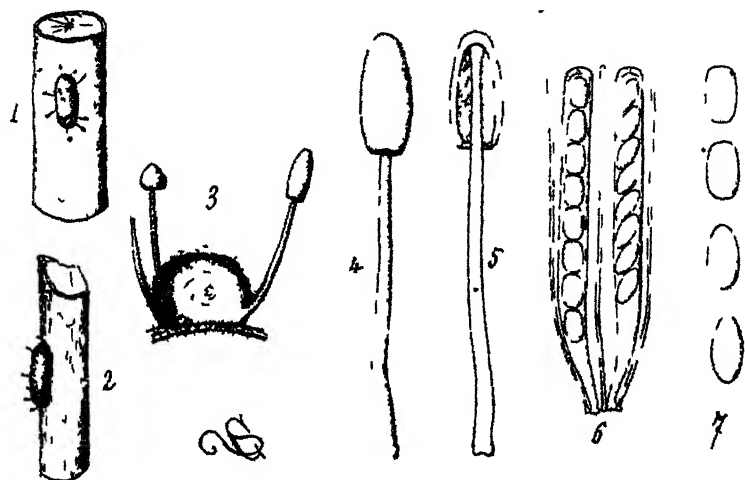


FIG 1. *Cudomopsis*, vista de arriba, 1/1; 2 *Cudomopsis*, vista de lado, 1/1; 3 Sección del esclerocio con dos ascomas, 6/1; 4. Ascoma entero, 20/1; 5. Ascoma seccionado verticalmente, 20/1; 6. Ascos y parafises, 125/1; 7. Esporas libres, 250/1.

bien separados uno de otro, hallándose formados por un estípite y una cabezuela; los estípites sencillos, rectos o arqueado-ascendientes son bastante largos pero delgados ( $1.5-5\ \text{mm. lng.} \times 100-150\ \mu$  diám.) lisos lampiños, a veces algo viscosos, rígidos pero no corneos, por dentro rellenos y del mismo color del esclerocio o un poco mas oscuros; la cabezuela o sombrerillo himenióforo en la primer edad es casi semiesférico con los bordes inferiores enroscados para adentro, mas tarde toma la forma de un dedal ( $500-750\ \mu$  lng.  $\times 200-350\ \mu$  diám.) y sus bordes son entonces derechos y arrimados al estípite, asemejándose a un pequeñísimo coprinus; su superficie externa e inferior es lisa de color ceniciento verdoso sin viscosidad, mientras la interna (aparentemente

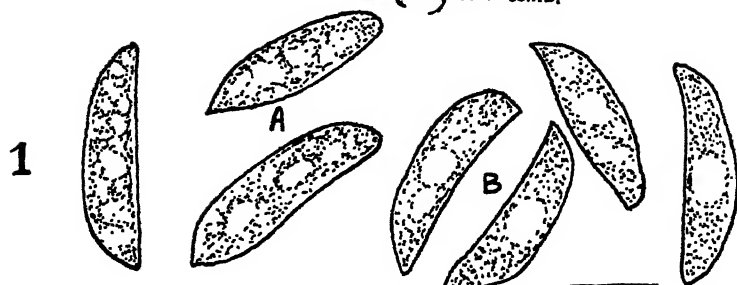
externa) y superior es también lisa, mas oscura olivacea y algo viscosa; el espesor de la pared himenofórica es limitado, variando de 90 a 110  $\mu$ ; cuando fresca es blanda y flexible, pero secándose se vuelve rígida y dura; estando constituida por dos capas, la inferior estéril fibrosa, la superior fértil ascófora; los ascos son cilíndricos (60–70  $\mu$  lng. x 6–8  $\mu$  diám.) en el ápice obtusamente redondeados casi truncados con membrana algo espesada y pequeña perforación central, posteriormente adelgazados en pedicelo relativamente corto que apenas alcanza a cuarta o quinta parte de la longitud total, conteniendo cada uno 8 esporas en una sola hilera vertical, y siendo acompañados de numerosos parafises filiformes de su misma longitud y sin engrosamiento ni ramificación apical; las esporas uniloculares son elipsoideas (6–8  $\mu$  lng. x 3.5–4  $\mu$  diám.), mas o menos obtusas en los extremos, revestidas de membrana delgada y lisa, sin vacuolos internos, transparentes, pero de color olivaceo pálido.

Bajo el acción de la tintura de yodo la extremidad superior de los ascos toma ligera coloración azul.

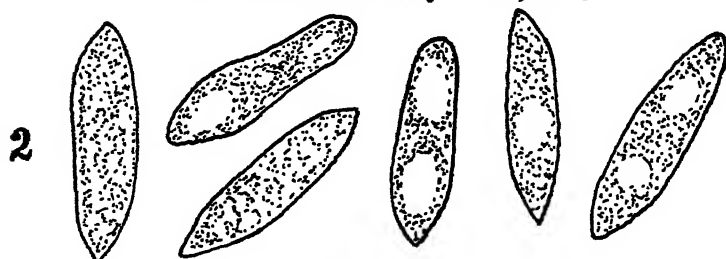
La PLATA, ARGENTINA.



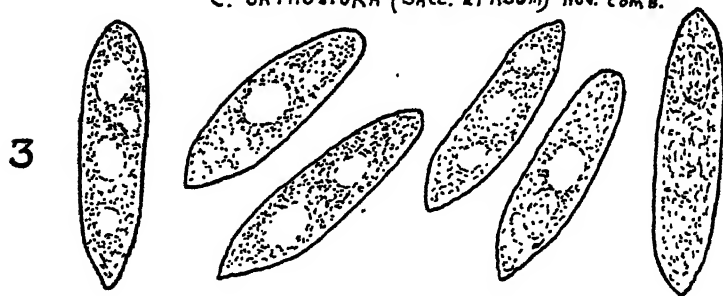
*C. MACULANS* (LK) nov. comb.



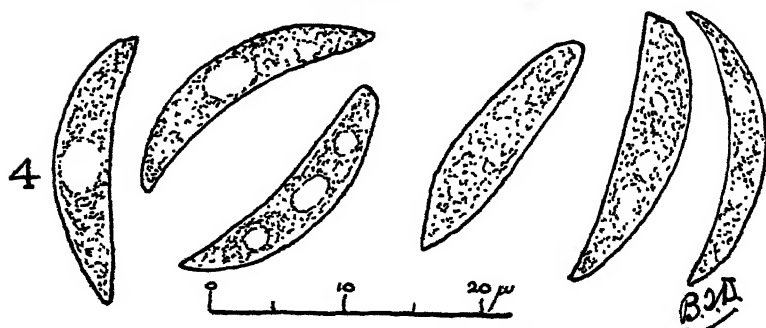
*C. ATRAMENTARIUM* (B. et Br.) TAUB.



*C. ORTHOSPORA* (SACC. et Roum) nov. comb.



*C. MINUTUM* (LK) nov. comb.



SPECIES OF COLLETOTRICHUM

## COLLETOTRICHUM v. VERMICULARIA

B. T. DICKSON

(WITH PLATE 21)

While engaged in a study of the organism concerned in a rather obscure potato disease—black-dot, dartrose, anthracnose or foot-rot—the writer examined exsiccati specimens of various species of *Vermicularia* occurring on potato. As a result of the examinations the question is raised as to the validity of the determinations and the fact becomes apparent that the genus *Vermicularia* needs thorough monographic study.

By the kindness of Dr. A. W. Hill, Director of the Royal Botanic Gardens at Kew, England, the following exsiccati were placed at my disposal: 1. *Vermicularia maculans* (Link) Desm.; 2. *Vermicularia atramentaria* B. & Br.; 3. *Vermicularia minuta* (Link) Lib.; 4. *Vermicularia orthospora* Sacc. & Roum.

### VERMICULARIA MACULANS

Link in his *Species Hyphomycetum et Gymnomycetum* (Species Plantarum Linnaei IV, 2: 123) of 1825 described *Exosporium maculans* as occurring on potato stems in France and Belgium. Fries in his index to volume 3 of the *Systema Mycologicum* (1829) gives *E. maculans* Link as a variety of *Vermicularia Dematium* Fr. which also occurs on potato stems. While spore sizes are approximately the same, those of *V. Dematium* are falcate and those of *E. maculans* straight, or but slightly curved. On this basis Desmazieres in his *Plantes Cryptogames du Nord de la France* renamed it *Vermicularia maculans*, which was accepted by Fries in his *Summa vegetabilium Scandinaviae* of 1849. It is described in the *Syll. Fung.* 3: 228 as:

“*Vermicularia maculans* (Link) Desm. Exs. n. 339, *Exosporium maculans* Link. Sp. plant. Fung. II, p. 123.—Peritheciis innatis, minutis, aggregatis, dein confluentibus et matricem nigrificantibus, rotundatis, applanatis, setulis concoloribus, sparsis, fasciculatis, apicem versus attenuatis, divaricatis obsitis, denique apice

hiantibus; sporulis (paucis) elongatis vel oblongis, rectis, sub-obtusis.

"*Hab.* in caulibus plantarum herbacearum, praecipue Solani tuberosi et Urticae urentis in Gallia et Belgio."

Examination of a small piece from the specimen showed the organism in various stages from that in which there was a small acervulus with spores and two setae to a setose sclerotial body with no spores.

The long desiccation of the specimen made it difficult to obtain good definition in photomicrograph, but it serves to illustrate the fact that the organism is not a *Vermicularia*. There is no true sporodochium and hence it may not be a *Volutella*. In my cultural studies of similar organisms the sclerotia occur either directly by the massing of mycelium giving a black pseudo-parenchymatous structure, which never bears spores (or but rarely and sparsely), or they are built up by mycelium growing around the bases of setae until the tips only of the setae project. In the latter case spores may still be borne on the up-growing mycelium. There is no evidence of differentiated cortical layer which afterwards ruptures such as described by Stevens (1) in his study of *Volutella circinans* (Berk.) Stevens.

Careful comparison of such slides as I have available leads to the conclusion that the organism known as *V. maculans* is a *Colletotrichum* inasmuch as the spores occur in acervuli with no evidence of sporodochia, and there is no evidence of a pycnidium warranting the name *Vermicularia*.

On this basis therefore *Vermicularia maculans* becomes *Colletotrichum maculans* (Link) comb. nov. with synonymy: *V. maculans* (Link) Desm.; *Exosporium maculans* Link.

Additional to the description in Sylloge Fungorum the following facts are now available. The spores are  $17.5-20\ \mu$  long by  $4-5\ \mu$  wide, straight to very slightly falcate. The surface of the spore turned to the middle of the acervulus is straight to slightly curved, while the outward-facing surface is curved and tapering suddenly at the ends. (See Pl. 21, fig. 1.) The sporophores are  $8-17.5 \times 3\ \mu$  and fascicled; the setae fascicled, bulbous at base,  $5\ \mu \times 125-150\ \mu$  and commonly thrice septate.

## VERMICULARIA ATRAMENTARIA

Berkeley and Broome's *Vermicularia atramentaria* appeared in 1850, and the technical account in Saccardo's Syll. Fung. 3: 227 is given herewith:

"Berkeley and Broome Ann. N. H. n 430.—Effusa, gregaria, atra, maculiformis; peritheciis minutis superne setulis longis rectis, basi vero fibris repentibus, subepidermicis cinctis; sporulis minutis, cylindraceis, brevibus, utrinque nucleatis, (plasmate utrinque retracto, Berk.).

"*Hab.* in caulibus Solani tuberosi in Britannia, Italia, Gallia, Belgio, Germania.—*Verm. maculans* (Link) Fr. Summa V. S. p. 420, Kickx Fl. Fl. I: p. 405, valde affinis est, nisi eadem ac *Verm. atramentaria* B. et Br."

Examination of this material leads to the conclusions that *V. atramentaria* is really *Colletotrichum atramentarium* and that it is not the same as *C. maculans*. The former conclusion was arrived at by Taubenhaus (2) in 1916 as a result of studies of material at the New York Botanical Garden and my studies support his view but not his synonymy. On page 554 of his paper the statement is made: "It seems evident that *Phellomyces sclerotiophorus* Frank is the same as *Vermicularia atramentaria* Berk. & Br. and also the same as *Colletotrichum solanicolum* O'Gara. However, in following the rule of priority, the fungus becomes *Colletotrichum atramentarium* (Berk. & Br.) Taubenhaus. Syn. *Vermicularia atramentaria* Berk. & Br., 1850; *Phellomyces sclerotiophorus* Frank, 1897; *Colletotrichum solanicolum* O'Gara, 1915."

Concerning this more will be said in another paper. The actual synonymy in my opinion is: *Colletotrichum atramentarium* (B. & Br.) Taub.; *Vermicularia atramentaria* B. & Br.; *Colletotrichum solanicolum* O'Gara.

The similarity between *C. maculans* and *C. atramentarium* is quite marked in appearance on the host in the exsiccati, in spore size, sporophore shape and size, setae and sclerotia. In fact until I had examined many spores, I was doubtful that there was sufficient specific difference. A majority of the spores of *C. maculans* are shaped somewhat like a glume or a lifeboat (naviculoid?) as in Plate 21, figure 1B with a minority like figure 1A. With *C. atramentarium* the majority of spores are short cigar- or torpedo-shaped as in figure 2. On this basis therefore they are maintained as different species.



## VERMICULARIA MINUTA

Libert renamed Link's *Exosporium minutum* in 1837 in his Pl. Crypt. Arduennae Fas. IV. No. 350. The specimen lent me by Dr. Hill was ex. Herb. Hort. et Bot. of Belgium and occurred in *caulibus herbarum aridis Autumno*.

This also has the characteristics of a *Colletotrichum* and not of a *Vermicularia* and hence should be *Colletotrichum minutum* (Link) comb. nov. with *Vermicularia minuta* (Link) Lib. and *Sphaeria Dematium* b *minor* Fries as synonyms.

The spores are slightly curved, fusiform, 20–22.5 by 3.75–5  $\mu$  (see Pl. 21, fig. 4); sporophores fasciculate, 15–22 x 3–3.75  $\mu$ ; setae 150–200 x 7.5  $\mu$ , often bulbous at base, tapering and rarely hyaline at tip. The statement is made in Saccardo, Syll. Fung. 3: 228, "An satis diversa a *Verm. Dematio*?" and the writer is awaiting an authentic specimen of *V. Dematium* to make the comparison.

## VERMICULARIA ORTHOSPORA

One specimen from Kew was from Roumeguère's collection and was labelled

"C. Roumeguère. Fungi selecti exsiccati

5463 *Vermicularia orthospora* Sacc. et Roum. Mich. II, p. 630—Syll. III, p. 227.

Sur Tiges desséchées du *Solanum tuberosum* Nordan (Coté d'Or) janvier 1890.

F. Fautrey."

This on examination was not a *Vermicularia* but appeared to be a *Colletotrichum* although not so many acervuli free from the pseudoparenchymatous sclerotial mass were obtained. Spores were 18.75–22.5 x 3.5–4.5  $\mu$  continuous, straight to slightly curved (see Pl. 21, fig. 3); sporophores 8–20 x 3–3.5  $\mu$ , fasciculate; setae 150–200 x 5–6  $\mu$ , slightly swollen at the base, slender and sometimes sub-hyaline at tip.

A second specimen from Kew (684 Coll. Libert) gave only sclerotial bodies, rarely setose, and with no spores.

A specimen kindly lent me by Dr. Seaver from the New York Botanical Garden was not an anthracnose but a pycnidium-producing organism.

Again therefore the *Vermicularia* should be a *Colletotrichum*, *Colletotrichum orthosporum* (Sacc. et Roum.) comb. nov.

## VERMICULARIA VARIANS

Ducomet in 1908 (3) described this organism causing dartrose of potato as follows:

"Pycnides éruptives superficielles à maturité, 15-150  $\mu$ , astomes, pourvues de poils noirs raides, de 100 à 130  $\mu$  x 3.5-4 biseptés, légèrement renflés à la base, atténués pâles au sommet. Spores un peu courbes, acuminées, hyalines, guttulées 18-22  $\mu$  x 2.5-3  $\mu$ . Stérigmates incolores ou à base brune 22-30  $\mu$  x 3-3.5. Espèce variable, évoluant vers les *Phoma* ou inversement vers les *Colletotrichum* et *Gloeosporium*."

"Parasite de la pomme de terre (tige, racine, rhizome, tubercule) de la tomate, du *Physalis peruviana*. (Ecole d'Agriculture de Rennes.)"

Dr. Pethybridge wrote me in December 1923 concerning this organism—that: "I no longer had *C. tabificum* in culture, but my former colleague, Mr. Lafferty, and I examined these cultures very carefully and could find no difference between them and our *C. tabificum*. We were, as you see, unable actually to make parallel cultures at the time, but I have no doubt that the two things are the same. Since then I have sent fresh material of *C. tabificum* on potato stalks from Lancashire, England, to M. Foex and in a letter to me dated the 14th of this month he states: 'L'identité de votre *Colletotrichum tabificum* avec le *Vermicularia varians* de Ducomet n'est pas douteuse.'"

Studies in my laboratory (4) confirm this and show further that it is the same as *Colletotrichum atramentarium* (B. & Br.) Taub.

In conclusion it may be inferred from the herein described studies on five so-called species of *Vermicularia* occurring on potato that further study of the genus is likely to demonstrate that still more are really species of *Colletotrichum*.

MACDONALD COLLEGE, MCGILL UNIVERSITY,  
CANADA.

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## PRELIMINARY SURVEY OF HYPOXYLON POPLAR CANKER IN OXFORD COUNTY, MAINE

E. J. SCHREINER

The following preliminary notes on *Hypoxylon* poplar canker pertains to the disease of poplar caused by *Hypoxylon pruinaum* (Klotzsch) Cooke, and was first described by A. Povah.<sup>1</sup>

The data recorded here were obtained in Oxford County, Maine, about seven miles from Andover. One set of figures was based on trees growing singly or in clumps on the cleared land along the road for a distance of about a mile. A second tally was made on a strip about 1.5 miles long and about 25 to 30 feet wide, extending up the side of the ridge to the east of the road. This hillside is covered by a mixed hardwood stand in which maple and paper birch predominate, with yellow birch and poplar (*P. tremuloides* Michx.) second in amount and with a scattering of beech and of conifers. The poplars, as is often the case, are not scattered, but occur in groups throughout the stand. Those in the forest stand are larger and older than the trees tallied in the open.

Cankers were tallied as *Hypoxylon* canker when they could be identified as such, otherwise they were recorded as unidentified. Some of the unidentified cankers were probably caused by *Hypoxylon*, and from previous observations it is suspected that most of the remainder were due to *Cytospora chrysosperma*, which is also common in this region.

The percentage of *Hypoxylon* canker in the open is almost twice that in the forest stand. The percentage of unidentified cankers on the other hand is less in the open than in the forest. These differences are no doubt due to some extent to the fact that in the open the cankers are lower and more readily identified. If the total number of all infections is considered, the trees in the

<sup>1</sup> Povah, A. *Hypoxylon* poplar canker. *Phytopathology* 14: 140-145. 1924.

TABLE I  
SHOWING NUMBER AND PERCENTAGES OF TREES INFECTED

	No. trees tallied	No. trees infected		Total no. infections	Per. trees infec.		Per. total infections
		Hypox. canker	Unident. cankers		Hypox. canker	Unident. cankers	
Trees in forest stand	226	25	20	45	11 + $\frac{1}{2}$ %	8.8 + $\frac{1}{2}$ %	20.1 + $\frac{1}{2}$ %
Trees in open . . .	103	22	4	26	21.3 + $\frac{1}{2}$ %	3.8 + $\frac{1}{2}$ %	25.2 + $\frac{1}{2}$ %

TABLE II  
SHOWING POSITION OF CANKERS ON TREES OF *Populus tremuloides*  
Trees in Mixed Hardwood Stand (Total No. trees tallied 226)

Dia.	Hypoxylon canker region infected			Unidentified cankers region infected			Healthy trees
	Upper $\frac{1}{2}$	Middle $\frac{1}{2}$	Basal $\frac{1}{2}$	Upper $\frac{1}{2}$	Middle $\frac{1}{2}$	Basal $\frac{1}{2}$	
2"-4"	1 + 3*		1	2 + 3	3 + 5	—	73
4"-8"	7 + 1			2 + 3	1	—	60
8"-12"	6 + 5	1		1	—	—	40
12" +	—	—	—	—	—	—	8
Totals	23	1	1	11	9		181

\* Italics indicate that trees are dead.

Trees Growing in Open (Total No. trees tallied 103)

2"-4"	7 + 1	2	3	1	1	2	71
4"-8"	—	1	6	—	—	—	6
8"-12"	—	—	1 + 1	—	—	—	—
12" +	—	—	—	—	—	—	—
Totals	8	3	11	1	1	2	77

open still show a higher percentage of infection. This may indicate a correlation between age and susceptibility (the trees in the open are younger), but the factor of spore dispersal must also be considered.

From the figures given above it is apparent that there is a difference in the position of the cankers on the trees in the open

and in forest growth. In forest growth almost all the cankers are in the upper one third of the tree, whereas on trees in the open the greatest number of cankers are near the base of the tree. This difference in the part of the tree infected may be due to several factors: the mode of spore dispersal, inability of spores to germinate on the older parts of bark, method of entry of the fungus (whether directly through the bark of the trunk or through a twig), and the factor of age of the tree.

There are several groups of *P. tacamahacca* Mill.<sup>2</sup> on the area in which these observations were made. These have originated as root sprouts from individual trees planted near old farm houses which have since been abandoned. No *Hypoxylon* canker was found on any of these although a wide range of ages was represented, and infected trees of *P. tremuloides* were close by. In considering stands of poplar from a silvicultural standpoint, the susceptibility of the species and varieties of poplar to this disease is to be taken into account. *P. tacamahacca* seems to be immune, and there are undoubtedly other species and varieties which are also more or less immune.

#### SUMMARY

1. Cankers on older trees in forest stands of poplar are found for the most part in the upper part of the trees. Cankers on trees in the open (younger trees) are found near the base of the tree.

2. For the same locality the percentage of infection in the open was 21%, in the forest stand it was somewhat lower.

3. No cankers were found on *P. tacamahacca* Mill.

THE NEW YORK BOTANICAL GARDEN,  
NEW YORK CITY, N. Y.

<sup>2</sup>Sargent, Notes on North American Trees. Jour. Arnold Arboretum 1: 61-63. July 1919.

## NOTES AND BRIEF ARTICLES

Dr. Chas. Thom, of Washington, recently visited the Garden in connection with work on *Aspergillus*. For a number of years Dr. Thom has been carrying on culture work with the plants of this genus and proposes soon to publish the results of his investigations.

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Professor H. M. Fitzpatrick, of Cornell University, spent some time at the Garden during the summer, continuing his studies on certain groups of the Pyrenomycetes, which are badly in need of revision.

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Dr. L. O. Overholts, of Pennsylvania State College, spent a part of his summer vacation as a research student at the Garden. Dr. Overholts devoted his time to a critical study of the basidiomycetes of Porto Rico, the results to be embodied in the Flora of Porto Rico and the Virgin Islands.

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Professor H. H. Whetzel, of Cornell University, spent some time at the Garden immediately after the close of the school year, continuing his studies of certain parasitic fungi destructive to ornamentals.

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The largest local morel which has come to our attention was recently brought into the laboratory by Mrs. Wheeler H. Peckham, having been collected in her garden at New Rochelle. The specimen measured four inches in diameter and nearly six inches high. The species is probably *Morchella crassipes*.

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Mr. Rafael Toro, of Porto Rico, who has been spending a year at Cornell University, was a summer student at the Garden. Mr. Toro is spending his time while in the states in a critical study of the fungi of Porto Rico. One paper has already been published by him in MYCOLOGIA.

Professor C. R. Orton has been granted a year's leave of absence from the Pennsylvania State College to take up investigations on seed-borne parasites for the Boyer Company, Inc., under the direction of the Crop Protection Institute. The work is being carried out at the Boyce Thompson Institute for Plant Research at Yonkers, N. Y., where most adequate facilities are being furnished both in laboratory and field. The studies include organic mercurial compounds as well as standard disinfectants for seeds and their effect upon plant growth.

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Dr. E. M. Gilbert, of the University of Wisconsin, has spent two months as a guest of the State Plant Board of Florida and during his stay has given attention to a study of the fungi that attack the aphids which is causing serious damage in the citrus groves of the state.

The studies, so far made, indicate that several fungi attack the aphids and efforts to culture some of these fungi will be continued by Mr. W. A. Kuntz of Pennsylvania State College, who is now stationed at the newly established Citrus Experiment Station at Lake Alfred, Florida. O. F. BURGER.

#### DISCOMYCETES OF AUSTRALIA

For several years past the writer has been in communication with Miss Ethel McLennan of Melbourne, Australia, who is making an intensive study of the genus *Lamprospora* and allied genera of cup-fungi. One of the facts brought out in the course of this work is the striking similarity between the species collected in Australia by her and those collected in North America by myself (see illustrations in MYCOLOGIA 6: pl. 114). Microscopic slides of the spores which furnish the chief diagnostic characters of the species of the genus are so similar that it is difficult and sometimes impossible to distinguish between those of the plants so widely separated geographically. In several cases she has been compelled to refer them to the names proposed for the North American species, while in other cases there is not more than a varietal difference.

The first paper dealing with the subject "Additions to the Australian Ascomycetes. No. 1" has recently appeared (Proc.

Roy. Soc. Victoria II. 35: 153-158. *pl.* 9, 10). In this paper Misses McLennan and Cookson record *Lamprospora tuberculata* Seaver as occurring in Australia, in this case the Australian and American plants being so similar that they could not be specifically separated. They also call attention to the fact that *Barlaea verrucosa* described by Rodway from Tasmania (Proc. Roy. Soc. Tasmania 1920: 158) is identical with the American species just named.

A new variety of a second species, *Lamprospora areolata* Seaver, variety *australis* McLennan and Cookson, is also recorded and well illustrated. The new variety is identical with the American species so far as spore characters are concerned. It differs, however, in the slightly larger size of the plants and in the delicate fringe which borders the apothecia, the latter character not having been noted in the American form. It is possible that even these apparent differences might disappear when the plant has been studied more extensively in this country. On account of the minute size of the plants, they are seldom seen, and the only American material of this species consists of a half dozen collections made in the vicinity of New York City by the writer. It is a pity that a wider interest cannot be had in these minute but extremely interesting forms of plant life. Such an interest would doubtless reveal a wide distribution for many of the species now so poorly known.

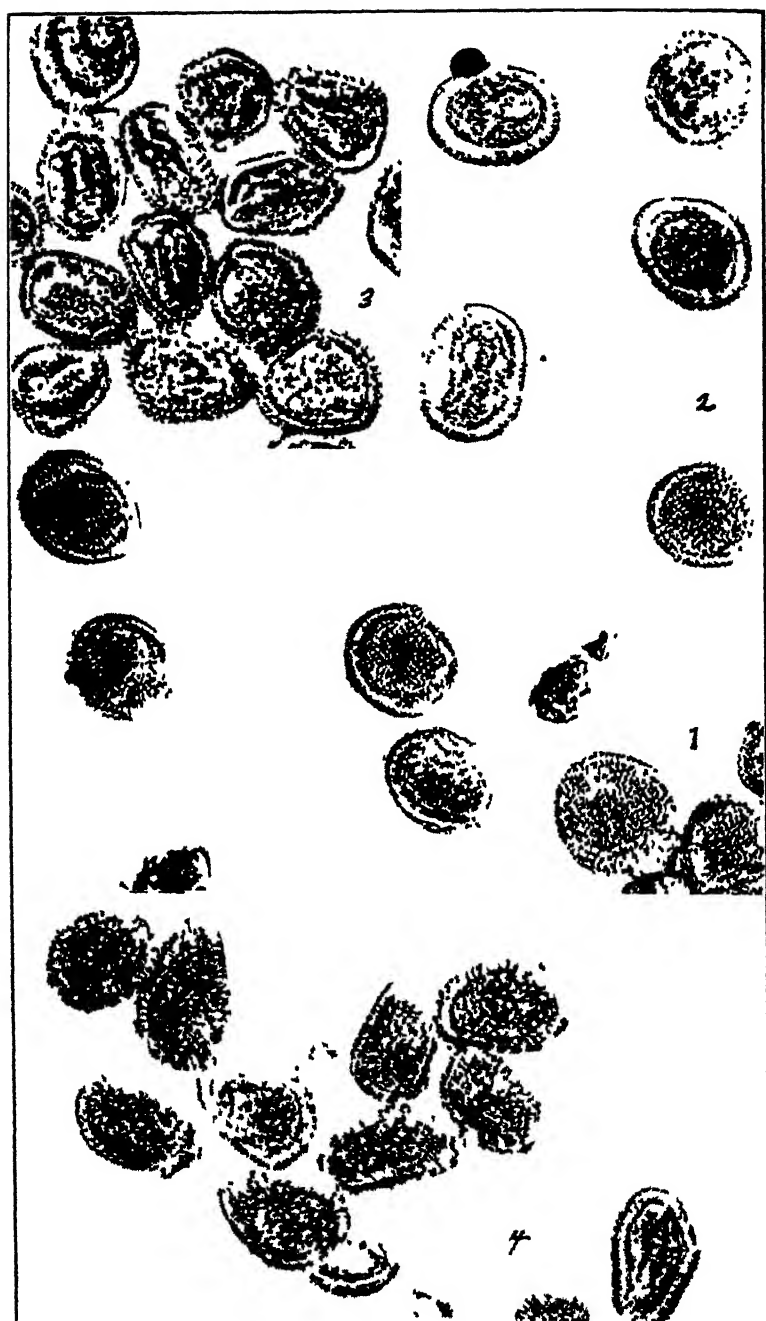
In the same paper a new species of *Sphaerosoma* is described, *Sphaerosoma alveolatum*. In the general appearance of the plants and spores this species is very similar to *Sphaerosoma echinulatum* of the writer which was later transferred to the genus *Boudiera*. The Australian plant differs, however, in having alveolate instead of echinulate spores. The authors of the Australian species seem to detect a difference in the apothecial characters between the American and Australian forms. So far as the writer can judge from the illustration the apothecial characters are very similar. The gradations also between the alveolate and echinulate characters of the spores are very misleading, so that we are inclined to wonder if the Australian plant is not also a species of *Boudiera*, identical with either the European or the American species which are themselves scarcely more than geographical forms of the same species.



Miss McLennan indicates in her correspondence that other species of *Lamprospora* have been collected by her which are apparently identical with American forms described by the writer, while still others appear to be undescribed. She and her associate are to be congratulated on the appearance of their first paper on this subject which we hope will be followed by others. Especially are we interested in their efforts to coördinate the mycological work of these two far away lands.

FRED J. SEAVER





COLEOSPORIUM

# MYCOLOGIA

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## THE GENUS *COLEOSPORIUM* IN THE NORTH-WESTERN UNITED STATES

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(WITH PLATES 22-24 AND 1 TEXT FIGURE)

The genus *Coleosporium* Lév. (Ann. Sci. Nat. III. 8: 373. 1847) includes only heteroecious species with distinct alternating phases which include pycnia, aecia, uredinia and telia, all of which are subepidermal. The aecia always appear upon the needles of pines and are very similar in appearance. In the earlier European literature, collections were not generally distinguished from the caulicolous rusts, and were referred to as *Peridermium Pini acicola* Wallr., or *P. oblongisporium* Fuckel. Collections of *Coleosporium Senecionis* Fr. on *Pinus silvestris* from an old collection of middle European fungi procured by the writer at Munich are so labeled.

The pycnia are inconspicuous, flat, linear, oval or elliptical structures appearing on both sides of the needle, but are generally on the concave side in one or two rows. When fresh they may be conspicuously yellow, the shade varying with the different species; later or when dry, they are brown or reddish. Some species may be readily distinguished by the color and shape of the pycnia.

The aecia appear on both sides of the needle, with a long or short cylindrical or flattened bladdery peridium which ruptures irregularly either at the top or sides. The cells of the peridium are colorless and usually strongly verrucose. The globose to oblong aeciospores have colorless walls with deciduous tubercles.

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Uredinia appear as pulverulent masses in some species with marginal paraphyses and break through the epidermis without a peridium and are at first yellow or orange, but soon fade. The globose to oblong urediniospores are abstricted in short chains with intercalary cells. The spore walls are hyaline, with conspicuous and usually deciduous tubercles. Size and markings of the spore walls are sometimes characteristic.

The telia appear as flat, dense, isolated or confluent, rounded or irregular, orange or yellow wax-like sori, composed of closely crowded teliospores. The young binucleated spore possesses a delicate exosporium enclosing a rich orange oily mass, which increases in quantity up to the time the spore is cut off from the basal cell by a cross wall. After the fusion of the two nuclei which follows the isolation of the spore from the parent mycelium the teliospore is stimulated to germinate internally at once and by two successive divisions, followed in each case by cell division, gives rise to the promycelium, which appears as a structure, an internal basidium with four cells arranged in a chain, one above the other. In some species the formation of secondary spore layers beneath the oldest or first has been observed, but it is not thought to be of any diagnostic value, since it is possible that this phenomenon may be common to all. A long sterigma is produced from each cell of the basidium *in situ* as soon as mature, on which is borne a globose or elliptical basidiospore.

The illustrations show that although morphologically the species of this genus are very much alike, they have in the case of some species very distinct spore characters. For the field worker, however, they are to be distinguished chiefly by their hosts. The color of the pycnia, shape, and position of the peridia are of importance in distinguishing the aecial stages which occur on 2- and 3-needled pines. Grove (10) points out as a possible specific character for certain British species, the occurrence of nearly all the aecia on one only of the two leaves of pines. He found this almost always true of *C. Senecionis* Fr. On the other hand, in some species the aecia occur on both needles of the fascicle. This he found to be the case usually with *C. Tussilaginis* Tul. The aecia of *C. Solidaginis* western form on *Pinus contorta* (TEXT FIG. 1) occur usually on one needle of the fascicle in

some collections, but exhibit considerable variation in this respect in other collections. On 3-needle conifers the aecia of this species may occur on all needles of the fascicle, but is usually confined to one. There is at present no adequate explanation why infection is confined to one or more needles of a fascicle. It is probable that owing to the more favorable position of one needle in a cluster more spores lodge on the face of it, hence only one needle is apt to be infested in light infections and more than one in heavy infections. Since species of this genus may be expected to infect a large series of 2- and 3-needle pines, it is not believed that any particular disposition of the aecia in a fascicle will occur with sufficient regularity to serve as a diagnostic character. Cultures show that there is a remarkable specialization on certain hosts or genera, but it does not necessarily follow that every species of *Coleosporium* on a certain telial host is a distinct species. Extensive and repeated cultures will determine these points, and is the most satisfactory means of definitely defining the limitation of species.

#### SYNOPSIS OF SPECIES IN RELATION TO THEIR HOST

##### Telia and uredinia on Carduaceae—

- On *Adenocaulon* ..... 1. *C. Adenocaulonis*.
- On *Madia* ..... 2. *C. Madiae*.
- On *Solidago* and *Aster* ..... 3. *C. Solidaginis*, western form.
- On *Senecio* ..... 4. *C. occidentalis*.
- On *Sonchus* . . . . . 5. *C. Sonchi-arensis*.
- Telia and uredinia on *Ribes* ..... 6. *C. ribicola*.

#### 1. COLEOSPORIUM ADENOCAULONIS Jackson, Brooklyn Bot. Gard. Mem. 1: 202. 1918

O, I and III. *Pycnia*, *aecia* and *telia* unknown.

II. *Uredinia* hypophyllous, very few, on inconspicuous yellowish spots, obscured by the pubescence of the leaf, small, 0.1–0.2 mm. across, orange-yellow, some fading to white, finally becoming pulverulent after the rupture of the epidermis; *urediniospores* globose to ellipsoid,  $16-24 \times 22-35.5 \mu$ , wall slightly yellowish when fresh, soon fading,  $2-3 \mu$  thick, conspicuously but not densely verrucose; pores not definitely demonstrated. Jackson states that they are indistinct.

On Carduaceae II.

*Adenocaulon bicolor* Hook., Washington, Oregon (type) and Idaho.

The rust is apparently very rare, but is apt to be overlooked owing to the inconspicuous nature of the infections. The pine hosts would necessarily have to be either *Pinus contorta* or *P. ponderosa*, or both.

2. COLEOSPORIUM MADIAE Cooke, Grevillea 7: 102. 1879. Type locality Sierra Nevada, Calif., on *Madia Nuttallii*

*Stichopsora Madiae* Syd. Ann. Myc. 2: 30, pl. 2, figs. 1, 2. 1904. *Coleosporium arnicale* Arth. N. Am. Fl. 7: 94. 1907. (See PLATE 22, FIG. 1 for the similarity of the Urediniospores with that of *C. Madiae*.)

O. *Pycnia* amphigenous, scattered, originating between mesophyl and cortical layer, not particularly noticeable, 0.5–0.8 mm. broad by 0.6–1 mm. long, about 95  $\mu$  high, brown to slightly reddish.

I. *Aecia* flattened laterally, 0.8–1.6 mm. long by 0.7–1.4 mm. high, peridial cells ellipsoid to ovoid in face view, sometimes acute at both ends, overlapping, 30–36 x 56 x 90  $\mu$ , the side walls 5–8  $\mu$  thick, the inner walls closely and evenly verrucose with more or less uniform papillae; *aeciospores* (PLATE 22, FIG. 2) broadly ellipsoid to ovoid, averaging 28.7 x 33.6  $\mu$ , range 25.5–32.2 x 28.9–38.9  $\mu$ , the walls 4.6  $\mu$ , varying in thickness, evenly verrucose, sometimes appearing smooth at one end due to the shortness and scarcity of the papillae.

II. *Uredinia* hypophyllous, 0.5–1 mm. across, early naked, bright orange-yellow fading to white, ruptured epidermis noticeable; *urediniospores* (PLATE 22, FIG. 3) ellipsoid to globose, average 26 x 30.2  $\mu$ , range 24.6–28.7 x 25.3–34.6  $\mu$ , walls medium but unequally thickened, 2.2 x 4.7  $\mu$ , densely, coarsely and irregularly verrucose with conspicuous and somewhat deciduous papillae. Probable overwintering under favorable conditions.

III. *Telia* hypophyllous, 0.5–1 mm. across, scattered or gregarious, often confluent, orange-yellow fading to pale yellow; *teliospores* with wall swelling 20–30  $\mu$  thick above, cylindrical or oblong-lanceolate, 16–20 x 48–65  $\mu$ , obtuse or acute at both ends; contents orange-yellow fading to colorless.

On Pinaceae O, I.

*Pinus Jeffreyi* "Oreg. Com.," Oregon.

On Carduaceae II, III.

*Madia racemosa* (Nutt.) T. & G., Washington.

*Madia sativa* Molina., Washington, Oregon.

*Madia citriodora* Greene, Oregon.

*Madia glomerata* Hook., Oregon.

*Madia ramosa* Piper, Oregon.

*Madia exigua* (Sm.) Greene, Oregon.

*General Distribution:* Pacific Coast of the United States.

Definite information on the life history of this rust has not been published. Field observations, however, point to an aecial connection on *Pinus radiata*. Near Waldo, Oregon, in 1916, the writer collected the rust on *Madia exigua* in direct association with aecia on the needles of *Pinus Jeffreyi*. The microscopical character of the rust on the latter host fully agrees with material collected by Boyce on *Pinus radiata* in Golden Gate Park, at San Francisco, and by Meinecke on the same host at Monterey. The above description of the aecia is drawn from the material collected at Waldo and is taken to represent the true aecial stage of *C. Madiae*.

The microscopical character of *Peridermium californicum* Arth. and Kern (4) based on material collected by Holway at Monterey, California, and said to be on *Pinus radiata*, differs from the material from which the above description is drawn. The aecia of *Peridermium californicum* are less conspicuous. The peridia] cells, of practically the same size, are usually more obtusely rounded at the ends with the inner walls more coarsely verrucose and thicker. The aeciospores (PLATE 22, FIG. 4), more variable in shape and not so regularly broadly ellipsoid, average  $27.9 \times 38.4 \mu$  (Arthur,  $25-29 \times 40-45 \mu$ ), range  $22.5-33.7 \times 33.3-44 \mu$ . The walls are thicker, average  $3.8-6.7 \mu$ , and are more coarsely and irregularly verrucose, with a greater tendency to appear smooth at one end. In addition, an examination of the structure of the needles of the type material shows a single vascular bundle. This, together with the fact that in one case in the writer's collection of the type the needles occurred in a bundle of four instead of three, indicates a misdetermination of the host. The needles in the type collection are small in diameter and length, averaging 7 cm. Those of *Pinus radiata* average 12 cm. in



length and are large and coarse with two distinct vascular bundles. This fact would indicate that the type collection of *Peridermium californicum* is probably on a white pine with unknown telial connection.

3. *COLEOSPORIUM SOLIDAGINIS* (Schw.) Thüm. Bull. Torrey Club 6: 216. 1878. (PLATE 23, FIGS. 1-4.) Western form

*Peridermium montanum* Arth. & Kern, Bull. Torrey Club 33: 413. 1906.

O. *Pycnia* amphigenous, scattered, inconspicuous, 0.3-0.5 mm. broad by 0.5-1 mm. long, low, conoidal, 55-65  $\mu$  high, reddish-brown.

I. *Aecia* (PLATE 23, FIG. 1) flattened laterally, 1-1.5 mm. long by 0.5-1 mm. high, rupturing irregularly; peridial cells large, ovoid to ellipsoid, 23-35 x 45-75  $\mu$ , colorless, delicate, *generally acute at both ends*, slightly overlapping and *easily separating*, the side walls 3-4  $\mu$  thick, rather minutely and regularly verrucose with short papillae of irregular shape (PLATE 23, FIG. 2); *aeciospores* (PLATE 23, FIG. 3) oblong to linear-oblong, average 19.9 x 29.9  $\mu$  (16-24 x 32-45  $\mu$ , Arth. and Kern), range 17.1-22.9 x 21.6-38.2  $\mu$ , the wall 2-3  $\mu$ , range 2-4.5  $\mu$ , closely and finely verrucose.

II. *Uredinia* hypophyllous, irregularly scattered or gregarious and crowded, 0.2-2 mm. broad, soon naked, orange-yellow when fresh, ruptured epidermis inconspicuous; *urediniospores* (PLATE 23, FIG. 4) globose, 19.9 x 27.4  $\mu$ , range 17.7-23.3 x 22.2-31.5  $\mu$ , *walls thick*, 2-4  $\mu$ , closely and finely verrucose with papillae of uniform height, contents orange-yellow when fresh, fading to colorless.

III. *Telia* hypophyllous, scattered or extensively confluent, depending on extent of infection, elevated when mature, 0.2-0.6 mm. or more across, yellowish to reddish-orange; *teliospores* with more or less uniform walls, occasionally swollen above to 25-35  $\mu$  thick, 15-25 x 40-75  $\mu$ , rounded at both ends; contents yellowish-orange becoming colorless when dry; basidiospores produced in decoctions of host, globose, 10 x 14  $\mu$ , yellowish-orange.

On Pinaceae O, I.

*Pinus contorta* Dougl., Wash., Oregon, Idaho and Montana (type), not on *Pinus ponderosa* var. *scopulorum* as reported.

On Carduaceae II, III.

On various species of *Aster* and *Solidago*, Washington, Oregon, Idaho and Montana.

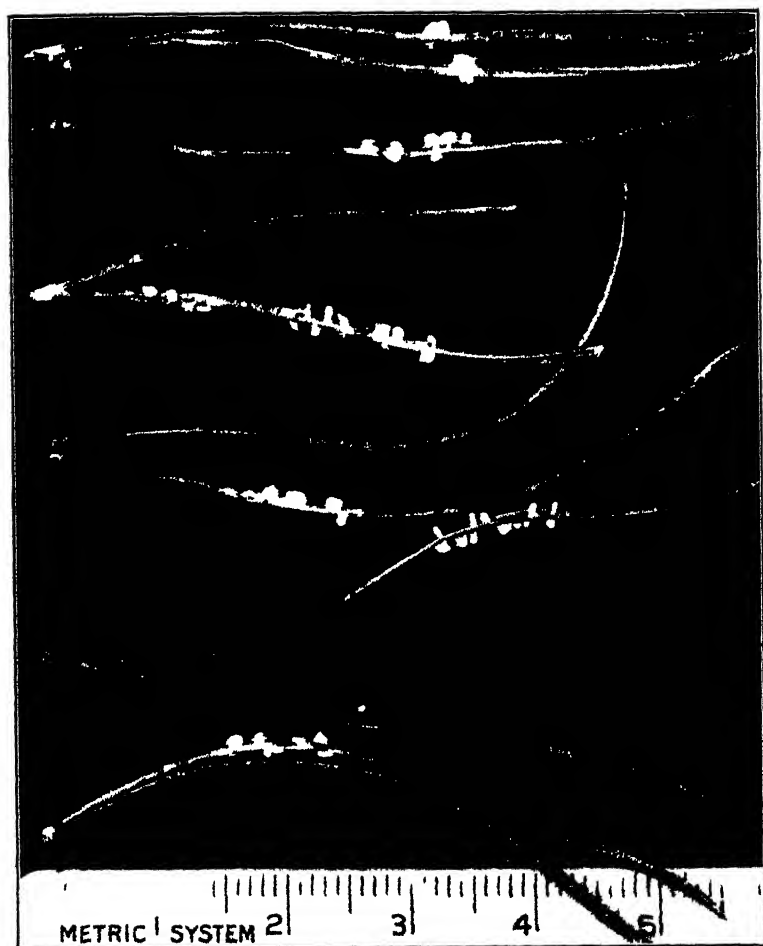


FIG. 1. *Coleosporium Solidaginis*, western form on needles of *Pinus contorta* showing infections on one and two needles of the fascicle

The life cycle of the western form of *Coleosporium Solidaginis* was first demonstrated by Hedgcock (12). He successfully inoculated *Aster conspicuus* with aeciospores from the needles of *Pinus contorta* collected near Bozeman, Montana. On the result of this experiment Hedgcock based his conclusions that the *Coleosporium* on *Aster* in the West is identical with *Coleosporium Solidaginis* of the East. This relationship was also suggested by Weir and Hubert (22). Arthur (2), however, in 1907 had already combined the two forms but did not hold the aecial stages

identical in a later publication (4). Jackson (14), although pointing out the dissimilarity between the two forms, recognizes but one American species. As first shown by Arthur and Kern, the aecia of two forms are morphologically distinguishable, a fact not considered by the former author in his latest publication (3).

In order to determine if the eastern form of *Coleosporium Solidaginis* would maintain its peculiarities when grown in the West on a western grown conifer, the following experiment was performed. In September, 1919, a quantity of leaves of *Solidago canadensis* L., bearing abundant telial sori from Scott County, Indiana, was intermingled with the needles of a young 4-year-old tree of *Pinus rigida* in one of the city parks at Spokane, Washington. On June 10, 1920, several needles bearing mature aecia were collected. There were no other infections in the neighborhood. It may be safely assumed that the aecial infection was a result of the inoculation with the Indiana material. This assumption was immediately verified by an examination of the minute characters of the aecia which were found to agree in every particular with eastern material. This experiment seems further to justify the conclusions that the eastern and western *Coleosporium* on *Aster*, *Solidago* and related genera are not identical.

For completeness and as a means of comparison, O, I, and II of the eastern form of *Coleosporium Solidaginis* may be described as follows:

O. *Pycnia* 0.3–0.5 mm. broad by 0.5–0.8 mm. long, low-conoidal, 80–100  $\mu$  high.

I. *Aecia* (PLATE 23, FIG. 5) flattened laterally, 0.5–1 mm. long by 0.6–1.2 mm. high; *peridial cells* (PLATE 23, FIG. 6) ellipsoid, rarely ovoid, 23–27  $\times$  40–70  $\mu$ , colorless, firm, with the ends generally obtuse, overlapping and not easily separating, the side walls 5–9  $\mu$  thick, very coarsely and prominently verrucose with closely set papillae of uniform size; *aeciospores* (PLATE 23, FIG. 7) regularly ellipsoid, average 24.8  $\times$  32.2  $\mu$  (20–24  $\times$  28–40  $\mu$ , Arth. and Kern), range 23.1–28.1  $\times$  23.5–41  $\mu$ , the wall varying in thickness, 3.6  $\mu$ , sometimes 8  $\mu$ , closely and coarsely verrucose, with prominent, somewhat deciduous tubercles, with a smooth spot extending up one side.

II. *Uredinia* hypophyllous, rarely also epiphyllous, irregularly

scattered and usually separated, 0.3–1 mm. broad, soon naked, yellow or orange when fresh, ruptured epidermis inconspicuous; *urediniospores* (PLATE 23, FIG. 8) generally globose, average  $20.4 \times 30.2 \mu$ , range  $15.6\text{--}23.8 \times 23.3\text{--}38 \mu$ ; walls rather thin, 1–2  $\mu$ , closely and coarsely verrucose with irregularly formed papillae; contents yellow when fresh, fading to colorless.

The life cycle of the eastern form of *Coleosporium Solidaginis* was first demonstrated by Clinton (7). He successfully inoculated *Solidago rugosa* with aeciospores from *Pinus rigida*.

With the same material with which he inoculated *Aster conspicuus* Hedgcock failed to infect *Solidago canadensis* which supports the suggestion by Sydow (20) that the form on *Aster* is different from the form on *Solidago*, and that it either represents an unattached species having a different aecial form or should be combined with the Asiatic *C. Asterum* (Diet.) Syd. Weir and Hubert (22), however, using aeciospores from *Pinus contorta*, successfully inoculated both *Aster* and *Solidago* obtaining infections on *Aster laevis* Geyeri, *Solidago canadensis* and *S. missouriensis*. The character of the uredinia and telia resulting from these inoculations on *Aster* and *Solidago* agreed in all essential details. This result, and subsequent experiments by the writer in the field whereby both *Aster* and *Solidago* were infected with the same aecial material, does not lend support to Sydow's view in the case of the western fungus. The writer has repeatedly transferred the rust by means of urediniospores from *Aster* to *Solidago* and from *Solidago* to *Aster*. It appears that similar experiments have not been performed in the case of the eastern rust.

The most recent work on these rusts is that of Hedgcock and Hunt (13). They state that the results of their inoculations indicate that in the eastern United States *C. Solidaginis* is a rust attacking species of *Solidago* but not those of *Aster*. The *Coleosporium* on species of *Aster* is apparently distinct from *C. Solidaginis*. *Peridermium montanum* Arth. and Kern apparently belongs to a rust on *Aster* and if so is distinct from *Peridermium acicolum* Underw. & Earle, the aecial form of *C. Solidaginis*.

The ability of the eastern form of *Coleosporium Solidaginis* to overwinter on rosettes of species of *Solidago* and *Aster* has been known for several years. Clinton (6), in 1906, first called atten-

tion to the occurrence of the uredinial stage of this rust on *Aster* and *Solidago* in Connecticut during the winter months. Ludwig (17), in 1914, reported a similar condition on *Aster* and *Solidago* in Indiana. Mains (18), in 1915, found the rust overwintering on rosettes of *Solidago*.

The overwintering of the western form of *Coleosporium Solidaginis* is also of common occurrence. The first observations were made in 1914, at which time urediniospores were found in abundance on *Solidago missouriensis* in midwinter. This condition was again demonstrated in 1916 (23) in the greenhouse at Missoula, Montana, on *Aster conspicuus* and *A. laevis* Geyeri. The leaves of rosettes of these species produced urediniospores throughout the winter. After cutting off all the leaves of the plant it was found that the new ones that developed from the stub were infected. Since there was no other source of infection, it would appear that the fungus was perennial in the stems. Since this time overwintering has been repeatedly observed on various species of *Aster* and *Solidago* and at such times of the year when only the rosettes of the plants were in evidence and before it was possible for the plants to be infected with aeciospores from pines.

Rhoads, Hedgcock, Bethel and Hartley (19), in 1918, report the overwintering of this rust on *Aster laevis*, *A. Porteri*, *Solidago missouriensis* and *S. oreophila* in Colorado.

4. COLEOSPORIUM OCCIDENTALIS Arth. N. Am. Fl. 7: 94. 1907.  
(PLATE 24, FIGS. 1, 2)

The first field evidence of the aecial connection of this rust is shown by a collection at Newport, Washington. A narrow-leaved form of *Senecio triangularis* from which 14 leaves were collected bearing uredinia and telia grew in close juxtaposition to a young 3-year-old seedling of *Pinus contorta* with aecial infection. Since species of *Aster* and *Solidago* on the same area were infected with *Coleosporium Solidaginis*, it was not possible to draw conclusions. The rust was again collected in August, 1916, on *Senecio triangularis* at Chelan Lake, Washington, in direct relation with aecia on *Pinus contorta*. In September of the same year the rust was found at Darby, Montana, on the

same hosts intermixed with *Coleosporium Solidaginis* on *Aster conspicuus*. In September, 1917, at Victor, Montana, aecia were found on needles of *Pinus contorta* in direct contact with *Senecio triangularis* which was sparingly infected with *Coleosporium occidentale*. *Coleosporium Solidaginis* was not found in the immediate neighborhood although species of *Aster* and *Solidago* were abundant. At Priest River, Idaho, the rust on *Senecio* was associated with Asters heavily infected with *Coleosporium Solidaginis*. Later the rust was again found on *Senecio* directly associated with aecia on *Pinus contorta* described under the name *Peridermium Weirii* Arth.

It would seem from the field evidence that the aecial host of this rust on *Senecio* may be as here indicated. A study of the minute character of the aecia associated with it on *Pinus contorta* shows some difference from that of *Coleosporium Solidaginis* on the same host. The aeciospores (PLATE 24, FIG. 1) are ellipsoid, often much elongated, average  $18.7 \times 29.6 \mu$ , range  $17.3-23.3 \times 21.6-36.7 \mu$ , walls coarsely and closely verrucose, thick,  $2.5-6 \mu$ . These characters conform somewhat to those for *Peridermium Weirii*. Since the infections on *Senecio* and the aecial stage on pine in at least two cases seem sufficiently conclusive, it may be that the aecial connection is as indicated. The whitish appearance of the uredinia and the absence of any pronounced reddish color of the telia of *C. occidentale*, also the sharply isolated areas affected, may serve to distinguish this rust on *Senecio* from *C. Solidaginis* on *Solidago* and *Aster*. The minute characters of the urediniospores (PLATE 24, FIG. 2) differ decidedly from those of the latter. The spores of the type material are as follows: globose to broadly ellipsoid, average  $25 \times 31 \mu$ , range  $20.1-27.6 \times 24.8-34.8 \mu$  (type description  $16-22 \times 25-33 \mu$ ), walls unevenly thickened, range  $2-6 \mu$ , evenly verrucose with short papillae. A complete description of the species will be withheld until the aecial stage has been definitely determined by cultures.

On Pinaceae O, I.

*Pinus contorta* Dougl.?, Washington, Montana.

On Carduaceae II, III.

*Senecio triangularis* Hook., Washington, Oregon, Idaho, Montana.

*Senecio hydrophiloides* Rydb., Falcon Valley, July 17, 1900,  
W. N. Saksdorp 586 (type), Washington.

5. COLEOSPORIUM SONCHI-ARVENSIS (Pers.) Lév.; Berk. Outl.  
Brit. Fung. 333. 1860

The following description is based on the collections of this rust made by Davis in Wisconsin:

O. *Pycnia* amphigenous, scattered, not numerous, originating between mesophyll and cortical layer, inconspicuous, 0.1–1 mm. long, 0.1–0.2 mm. broad, 60–90  $\mu$  high, dehiscent by a longitudinal slit.

I. *Aecia* amphigenous, not numerous, scattered, laterally compressed, erumpent from longitudinal slits, 1–2 mm. long, 0.1–2 mm. high, peridium irregularly dehiscent, delicate, white, cells overlapping, 34–70  $\mu$  long, 17–33  $\mu$  broad, inner wall moderately verrucose, moderately thick, 3–5  $\mu$ , outer wall less rough; *aeciospores* ellipsoid to globose, 20–34 x 16–26  $\mu$ ; wall colorless, densely verrucose, moderately thick, 2–3  $\mu$ .

II. *Uredinia* hypophyllous, small, round or in irregular groups, yellowish-orange fading to white, ruptured epidermis not prominent; *urediniospores* ovate to subglobose, 18–28 x 15–21  $\mu$ ; wall thin, 0.1–1.2  $\mu$ , densely and finely verrucose.

III. *Teria* hypophyllous, scattered, small, often confluent, 0.3–0.7 mm. in diameter, yellowish-red fading to yellowish-brown; *teliospores* cylindrical or clavate-oblong, 75–100 x 14–25  $\mu$ , rounded or obtuse at each end, wall at summit 14–18  $\mu$  thick; contents orange-red fading to colorless.

On Carduaceae II, III.

*Sonchus arvensis* L., Hillyard, Spokane Co., August 27, 1915.

This collection was made along the track of the Great Northern Railroad and has not again appeared. It was evidently introduced.

The life history of this species was first demonstrated by Ed. Fischer (9). He inoculated needles of *Pinus silvestris* with teliospores from *Sonchus asper* in the autumn of 1893, and obtained pycnia and aecia the following spring. With the aeciospores thus obtained he successfully inoculated *Sonchus oleraceus*. Fischer's results were verified by Klebahn (15) in 1895, using teliospores from *Sonchus asper*. Later Wagner (21) inoculated pines in September and obtained pycnia in the middle of November.

In 1913 Davis (8) collected the aecia of this rust near Sturgeon Bay, Wisconsin, on *Pinus silvestris* in direct relation with the telial stage on *Sonchus asper*. In 1915, and again in 1918, he collected the rust on *Pinus silvestris*, *P. Banksiana* and *Sonchus asper*. This rust is mentioned by Bailey (5) and Halsted (11) as occurring on China asters. They give methods of control. Williams (24) refers to the occurrence of this rust in South Dakota.

6. COLEOSPORIUM RIBICOLA (Cooke & Ellis) Arth. N. Am. Fl. 7:  
86. 1907. (PLATE 24, FIGS. 3-5)

*Uredo ribicola* Cooke & Ellis, Grevillea 6: 86. 1878.

*Uredo Jonesii* Peck, Bull. Torrey Club 12: 36. 1885.

On Pinaceae O, I. Not known to occur in the states covered by this paper.

On Grossulariaceae II, III.

*Ribes cereum* Dougl., Montana.

*Ribes inermis* Rydb., Montana.

The aecial connection of this rust on *Ribes* was first demonstrated by Long (16) in 1916 by inoculations on *Ribes leptanthum* and *R. longiflorum* with aeciospores from *Pinus edulis*. This host was also similarly infected by Hedgcock and Hunt (13). In the same year the needles of *Pinus pinea* were successfully inoculated with telia from *Ribes inebrians* from Boulder, Colo., by Hedgcock and Hunt (19). The following year Hunt, using aecial material from Colorado, successfully inoculated the leaves of *Ribes inebrians* (19). The occurrence of this rust northward beyond the limits of the range of its aecial host implies that it either winters over in the uredinal stage or has aecial hosts not yet determined. It may be expected to occur on *Pinus ponderosa* and *P. contorta*.

The concentric arrangement of the uredinal and telial sori on the leaves of its host (PLATE 24, FIG. 3) sometimes characterizes the species. The pycnia were described by Hedgcock and Hunt (13) as conspicuous in single short rows on chlorotic spots in leaves, hazel to chestnut brown when old, 0.4 mm. wide by 0.7 mm. long. The urediniospores (PLATE 24, FIG. 4) and aeciospores are very characteristic. The former are smaller than



those of any western species so far studied. They are more or less uniformly globose, average  $19.9 \times 22 \mu$ , range  $17.5-21.6 \times 18.8-24.4 \mu$ . The walls are thick, unequal, average  $2.6-4.3 \mu$ , and densely verrucose with slender cylindrical tubercles. The aeciospores (PLATE 24, FIG. 5) are ellipsoid to globose, average  $21.7 \times 26.1 \mu$ , range up to  $24.4 \times 29.8 \mu$ . The walls vary in thickness from  $2.6$  to  $4.5 \mu$  and are densely and evenly verrucose.

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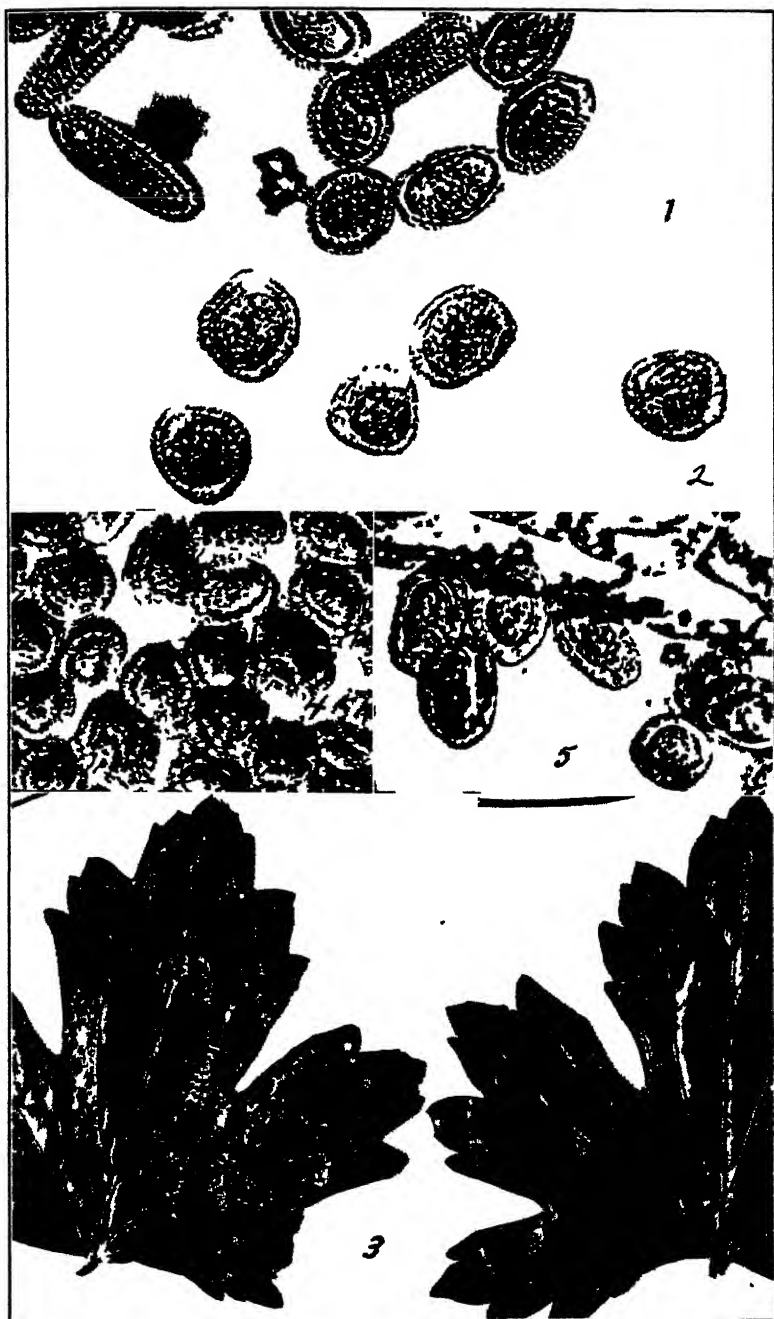
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## ILLUSTRATIONS

Photographs by Dr. A. S. Rhoads unless otherwise indicated.

## EXPLANATION OF PLATES

## PLATE 22

- Fig. 1. Urediniospores of *Coleosporium arnicale* (*C. Madiæ*) on *Arnica cana*.  $\times 532$  (type).
- Fig. 2. Aeciospores of *Coleosporium Madiæ* on needles of *Pinus radiata*.  $\times 532$ .
- Fig. 3. Urediniospores of *Coleosporium Madiæ* on *Madia exigua*.  $\times 532$ .
- Fig. 4. Aeciospores of *Peridermium californicum* on *Pinus* sp.  $\times 532$  (type).

## PLATE 23

- Fig. 1. Aecia of *Coleosporium Solidaginis* western form on *Pinus contorta*.  $\times 7\frac{1}{2}$ .
- Fig. 2. Peridial cells of *Coleosporium Solidaginis* western form from aecia on *Pinus contorta*.  $\times 532$ .
- Fig. 3. Aeciospores of *Coleosporium Solidaginis* western form on *Pinus contorta*.  $\times 532$ .
- Fig. 4. Urediniospores of *Coleosporium Solidaginis* western form on *Solidago missouriensis*.  $\times 532$ .
- Fig. 5. Aecia of *Coleosporium Solidaginis* eastern form on *Pinus rigida*, Takoma Park, Md., from material used by Hedgcock to successfully inoculate *Solidago serotina*.  $\times 4$ . Photo by Hedgcock.
- Fig. 6. Peridial cells of *Coleosporium Solidaginis* eastern form on *Pinus rigida*, Takoma Park, Md.  $\times 532$ .
- Fig. 7. Aeciospores of *Coleosporium Solidaginis* eastern form on *Pinus rigida*, Takoma Park, Md.  $\times 532$ .
- Fig. 8. Urediniospores of *Coleosporium Solidaginis* eastern form on *Solidago serotina*, from above named inoculation, Takoma Park, Md.  $\times 532$ .

## PLATE 24

- Fig. 1. Aeciospores of *Coleosporium occidentale* on *Pinus contorta*.  $\times 532$ .
- Fig. 2. Urediniospores of *Coleosporium occidentale* on *Senecio hydrophiloides*.  $\times 532$  (type).
- Fig. 3. Uredinial and telial sori of *Coleosporium ribicola* on *Ribes aureum*, natural size. Photo by Hedgcock.
- Fig. 4. Urediniospores of *Coleosporium ribicola* on *Ribes inebrians*.  $\times 532$ .
- Fig. 5. Aeciospores of *Coleosporium ribicola* on *Pinus edulis*.  $\times 532$ .

## NOTES ON THE PARASITIC FUNGI OF ILLINOIS—II

L. R. TEHON AND EVE DANIELS

(WITH PLATE 25)

As stated in a previous paper (MYCOLOGIA 16: 135-142. 1924) it is our purpose to bring together, as often as time and material make it expedient, the novelties and the interesting species of parasitic fungi collected by the botanists of the Illinois State Natural History Survey. This paper is the second in what the writers hope will prove an interesting series.

### **Phacidium Negundinis** Tehon & Daniels, n. sp.

Cankers extensive on small twigs, thickly dotted with the ascomata, bark remaining dark. Ascomata abundant, irregularly scattered, lying in the epidermis and rupturing epidermis and cuticle at maturity, irregularly stellate in dehiscence, 150-300  $\mu$  in diameter. Asci cylindrical to saccate, short- or non-stipitate, 60-70 x 14-17  $\mu$ ; paraphyses filiform, exceeding the asci. Ascospores continuous, ovoid to oblong, hyaline to greenish, uniformly 20 x 27  $\mu$ , protoplasm granular.

On diseased twigs of *Acer Negundo*.

Urbana, Champaign County, Illinois, June 3, 1922. Acc. No. 8890 (type).

The caulicolous habit, the much larger asci and the very large spores furnish ready means of distinction between this species and *P. minutissimum* Awd., which is also reported on *Acer*.

### **Mycosphaerella cornicola** Tehon & Daniels, n. sp.

Inhabiting the dead bark, lesions not definitely marked. Perithecia large, black, spherical, semi-erumpent, 150-225  $\mu$  in diameter, ostiole 10-15  $\mu$  wide; the perithecium connected with an extensive subiculum of dark brown hyphae which penetrate throughout the decomposed cortex. Asci clavate, 55-70 x 14-18  $\mu$ , 8-spored. Ascospores 1-septate, biseriata or irregularly arranged, ochraceous, oblong-cylindrical, with rounded ends, the basal half often somewhat tapered, cells approximately equal, the spore 20-30 x 6-7.5  $\mu$ .

In bark of *Cornus stolonifera*.

Apple River Canyon, Jo Daviess County, Illinois, July 17, 1924. Acc. No. 13596 (type).

With this occurs a *Phoma*, so evidently associated as to suggest itself as the pycnidial form. It is described later. The characters of spore and ascus are depicted in PLATE 25, FIG. 1.

***Phyllosticta Aquilegiae* Tehon & Daniels, n. sp.**

Spots circular or subcircular, extensive, 0.5–3 cm. or more in diameter, concentrically marked with rings, brown or reddish-brown. Pycnidia abundant, often crowded, arranged without reference to each other or to the marks on the spot, parenchymatic, yellowish, ostiolate, 105–120  $\mu$  in diameter; ostiole 10–15  $\mu$  wide. Spores hyaline, ovoid to oblong, 3.5–4  $\times$  7.5–11  $\mu$ , biguttulate, very rarely appearing bilocular.

On leaves of *Aquilegia canadensis*.

Marion, Williamson County, Illinois, July 19, 1922. Acc. No. 2098 (type).

The greater length and width of the spores distinguish this species from *P. aquilegicola* Brun.

***Phyllosticta pteleicola* Tehon & Daniels, n. sp.**

Spots circular or subcircular, ochroleucous, depressed, apparent on both sides of the leaf, 1–2 mm. or rarely 5 mm. in diameter. Pycnidia apparent above only, where the ostioles are erumpent, globose, carbonaceous, 60–100  $\mu$  in diameter. Spores hyaline, ovoid, 3.7 to 6.5  $\mu$ .

On leaves of *Ptelea trifoliata*.

Starved Rock, La Salle County, Illinois, June 27, 1924. Acc. No. 6807 (type).

This differs from *P. Pteleae* Hollós in its smaller pycnidia and smaller, uniform spores, and from *P. hesperidearum* (Catt.) Penzig, which is parasitic upon Rutaceae in Europe, in spot characters, pycnidia and spores. The latter species, reported upon a cultivated *Citrus* in Colorado, probably has not strayed to our common native shrub.

***Phyllosticta Allii* Tehon & Daniels, n. sp.**

Spots very extensive, white, and thickly dotted with the black, evident pycnidia. Pycnidia numerous, carbonaceous, spherical



or elongated between the veins, 60–160  $\mu$  in diameter; ostiole prominently erumpent, 15  $\mu$  wide. Spores hyaline, oval, 1-guttulate, 3.7 x 7.5  $\mu$ .

On *Allium Cepa*.

Columbia, Monroe County, Illinois, August 24, 1922. Acc. No. 11132 (type).

**Phomopsis Callistephi** Tehon & Daniels, n. sp.

Caulicolous, causing cinereous cankers 3–5 cm. or more long and 1–1.5 cm. wide. Pycnidia abundant, scattered, black, becoming erumpent, 100–150  $\mu$  in diameter; ostiole 15  $\mu$  wide. Spores hyaline, ovoid but variable, 3.5 x 7.5  $\mu$ ; ends pointed. Stylospores filiform, curved, hyaline, apparently non-septate, 15–20 x 1–2  $\mu$ .

On stems of *Callistephus hortensis*.

Shelbyville, Shelby County, Illinois, September 20, 1924. Acc. No. 2014 (type).

In addition to its mycological newness, this species is of interest as the cause of a serious stem canker on an important floricultural plant. It is reported to have been prevalent and destructive throughout the summer of 1924 in the locality mentioned, causing the death of large numbers of plants.

**Chaetomella Triticum** Tehon & Daniels, n. sp.

Pycnidia superficial, connected with a ramose, brown mycelium within the host, densely setose, black, 75–100  $\mu$  in diameter. Setae straight, simple or one to several times dichotomously branched, tips obtuse, 200–300  $\mu$  long, branches often 30–40  $\mu$  long. Spores spherical to ovoid, olivaceous to brown, continuous, 4.4–5  $\mu$  in diameter.

On the inner surfaces of wheat glumes taken from prematurely dying heads.

Waterloo, Monroe County, Illinois, August 24, 1922. Acc. No. 971 (type).

The branched setae, illustrated in FIGURE 3, are reminiscent of *C. horrida* Oud.

**Sphaeropsis Negundinis** Tehon & Daniels, n. sp.

Cankers extensive on small twigs, thickly dotted with the scattered pycnidia. Pycnidia spherical, ostiolate, usually only

the ostiole protruding, nearly black, parenchymatically reticulate, 130–150  $\mu$  in diameter, the ostiole 15–17  $\mu$  wide. Spores ovoid to oblong, hyaline when young, becoming brown at maturity, non-septate, one-guttulate, often with a slight but evident geniscar, uniformly 11  $\times$  20  $\mu$ ; protoplasm appearing distinctly granular. (PLATE 25, FIG. 4.)

On diseased twigs of *Acer Negundo*.

Urbana, Champaign County, Illinois, June 3, 1922. Acc. No. 15198 (type).

The size and aspect of the spores of this species are suggestive of *S. grandinea* Ellis & Ev. and *S. simillima* Peck., both of which are reported on *Acer* sp. from Illinois. Pycnidia in our species are only half as large, however; and it is not likely that the Harpers, in their collecting, would have failed to distinguish between the maples and the box elder. Hence we are led to regard our material as specifically distinct. The enormous size (400–500  $\mu$ ) of the pycnidia of *S. acerina* Ellis & Barth. precludes any possibility of confusion with it.

#### **Coniothyrium Negundinis Tehon & Daniels, n. sp.**

Cankers at the bases of small twigs, thickly dotted with pycnidia. Pycnidia scattered or frequently gregarious and even congregarious, black, ostioles protruding, 225–300  $\mu$  in diameter. Spores small, hyaline when young, olivaceous at maturity, spherical to ovoid, 2.2–4.4  $\mu$  in diameter.

On *Acer Negundo*.

Urbana, Champaign County, Illinois, June 3, 1922. Acc. No. 13413 (type).

Its larger pycnidia and much smaller, nearly spherical spores differentiate this species from *C. olivaceum* var. *Aceris* Ferraris, reported on *Acer*.

#### **Cryptostictis Paeoniae Tehon & Daniels, n. sp.**

Spots variable in size, 1–10 mm. in diameter, round to oval, tan to brown, definitely limited by a raised concolorous margin. Pycnidia black, spherical, papillate-roughened, semi-erumpent, 75–120  $\mu$  in diameter; ostiole 10  $\mu$  wide. Spores hyaline to greenish, 3-septate, nearly straight to falcate, 14–15  $\times$  4–5  $\mu$ , walls of central 2 cells distinctly heavier; setae one to each terminal cell, hyaline, 3–4  $\mu$  long. (PLATE 25, FIG. 5.)

On leaves of *Paeonia officinalis*.

Bloomfield, Johnson County, Illinois, July 25, 1922. Acc. No. 6024 (type); Tampico, White County, August 15, 1922. Acc. No. 2065.

*Monochaetia Paeoniae* (Maubl.) Sacc. & D. Sacc., which produces its acervuli on the branches of *Paeonia arborea*, has many characteristics in common with our species; and the two may be, as is true of other "Imperfecti," variations of the same fungus. We have not seen intergrading forms in connection with our species, however, and therefore prefer to record it separately.

***Cryptostictis Violae* Tehon & Daniels, n. sp.**

Spots large, diffuse, yellow or tan, unlimited except by the veins, circular to oval, 0.5–1.5 cm. or more in diameter. Pycnidia abundant, scattered but most numerous toward the periphery of the spot, flask-shaped, the ostiole extruded or often the upper half of the pycnidium erumpent, dark brown, parenchymatically reticulate, 60–80  $\mu$  in diameter. Spores hyaline, 3-septate, often slightly curved, 2.2–3.5  $\times$  14–16  $\mu$ . Bristles of the terminal cells hyaline, slightly curved, filiform, 8–10  $\mu$  long. (PLATE 25, FIG. 6.)

On leaves of *Viola* sp.

Rushville, Schuyler County, Illinois, July 13, 1922. Acc. No. 16631 (type).

***Septoria Floridae* Tehon & Daniels, n. sp.**

Spots more or less angular, limited by the veins, 1–3 mm. in diameter, frequently confluent, at first brown and surrounded by a raised, darker brown border, later ashen to white and surrounded by a darker red or black margin, the whole furnished with a diffuse purplish halo, more apparent above. Pycnidia abundant in the older spots, scattered, erumpent above, spherical, 60–75  $\mu$  in diameter. Spores hyaline, cylindrical, obtuse, often somewhat curved, 1–3 septate, 16–22  $\times$  3.5–4  $\mu$ .

On leaves of *Cornus florida*.

Thebes, Alexander County, Illinois, August 17, 1922. Acc. No. 595 (type).

It is impossible to reconcile this species with *S. cornicola* Desm., which we also have in Illinois. There are differences in the size and character of the spots and in the spores, which,

though apparently slight, are remarkably constant. Our species also has shorter spores than Peck's *S. canadensis*; and there are considerable differences in spot characters and spore width which separate it from Saccardo's *S. Corni-marit*.

**Phaeoseptoria Caricis** Tehon & Daniels, n. sp.

Spots small, 0.5–3 mm. long by 0.25–1 mm. wide, brown or tan, with a halo of purple extending several cm. along the leaf and uniting adjacent spots. Pycnidia few, scattered, rarely partially erumpent, parenchymatous, not carbonaceous, spherical or often becoming elliptical between veins, 70–100  $\mu$  in diameter. Spores long, cylindrical, olivaceous, one end acute, 7–10 septate, 70–80  $\times$  7  $\mu$ . (PLATE 25, FIG. 7.)

On leaves of an unidentified *Carex*.

Ursa, Adams County, Illinois, June 28, 1922. Acc. No. 15455 (type).

**Leptothyrium maximum** Tehon & Daniels, n. sp.

Cankers relatively small, one internode in extent, thickly studded with pycnidia which are arranged in rows lengthwise of the twig. Pycnidia circular, dimidiate, subcuticular, 500–750  $\mu$  in diameter, parenchymatically reticulate; ostiole irregular, 20–40  $\mu$  wide. Spores ovoid to oblong, hyaline, thick walled, 20–25  $\times$  11  $\mu$ .

On diseased twigs of *Acer Negundo*.

Urbana, Champaign County, Illinois, June 3, 1922. Acc. No. 1795 (type).

The extremely large size of the pycnidia and the larger spores are characters which distinguish this species as different from those now known on *Acer*.

**Colletotrichum Smilacinae** Tehon & Daniels, n. sp.

Spots very large and long, 1–1.5  $\times$  2–6 cm., lying between the large veins and extending lengthwise of the leaf, white and papery with a very narrow but evident dark red margin, apparent both above and below. Acervuli numerous, scattered, generally epiphyllous, 30–105  $\mu$  in diameter. Setae numerous, long, slender, straight or curved, rigid, tapering to a subacute tip, dark brown throughout, 100–300  $\times$  3.5–4  $\mu$ , with a bulbous base 6–10  $\mu$  thick. Conidiophores short, blunt, hyaline, 6–9  $\times$  2–3  $\mu$ . Spores spindle- to boat-shaped, hyaline to greenish, both ends acute, 19–23  $\times$  3–4  $\mu$ .

On leaves of *Smilacina racemosa*.

Goreville, Johnson County, Illinois, June 22, 1924. Acc. No. 7259 (type).

***Cercospora Abutilonis* Tehon & Daniels, n. sp.**

Spots circular or subcircular, often confluent, 0.5–3 mm. in diameter, tan to brown above with a darker margin, less evident below. Fasciculae epiphyllous, scattered, upright, rarely of more than 3 hyphae. Conidiophores upright, straight or slightly flexed, 2–4 septate,  $30\text{--}70 \times 3.5\text{--}4 \mu$ , with a distinct and characteristic purplish tinge added to their olivaceous color. Spores hyaline, oblong, with rounded ends, mostly without septa but often 1–3 septate,  $17\text{--}20 \times 3.5\text{--}4 \mu$ . (PLATE 25, FIG. 8.)

On leaves of *Abutilon Theophrasti*.

Spring Valley, Bureau County, Illinois, August 17, 1922. Acc. No. 963 (type).

The spores of this species, which were found in abundance on the spots, are at once suggestive of a *Ramularia*, as may be seen in FIGURE 8. The evident, fuscous conidiophores mark it as a *Cercospora*, while the spore measurements and the distinctive purple tint of the hyphae readily separate it from *C. althaeina* Sacc., which has also been reported on *Abutilon*.

***Cercospora Arborescentis* Tehon & Daniels, n. sp.**

Spots round or slightly angular, at first dark brown to black but later becoming cinereous with a definite black border, reaching 3 mm. in diameter. Fasciculae epiphyllous, scattered, ascending. Conidiophores flexuous, septate, brown, with light-fuscous apical cells. Spores hyaline, 3–5 septate, obclavate,  $55 \times 4.5\text{--}5.5 \mu$ .

On leaves of *Hydrangea arborescens*.

Thebes, Alexander County, Illinois, August 17, 1922. Acc. No. 599 (type).

***Cercospora Decodontis* Tehon & Daniels, n. sp.**

Foliicolous; spots subcircular to angular, brown, limited, with a darker, sometimes reddish, border, 1–3 mm. in diameter. Fasciculae almost entirely epiphyllous, numerous, scattered. Conidiophores fuliginous, upright, simple, 1–2 septate, nearly straight except at the tips where numerous crowded genicars contribute to an evident irregularity,  $40\text{--}110 \times 4 \mu$ . Spores

hyaline to smoky, straight or slightly curved, somewhat obclavate, 2-5 septate,  $40-95 \times 3.5 \mu$ .

On *Decodon verticillatus*. (PLATE 25, FIG. 9.)

Wolf Lake, Union County, Illinois, August 16, 1922. Acc. No. 17196 (type).

***Cercospora menthicola* Tehon & Daniels, n. sp.**

Spots numerous (on the type), circular or subcircular, 0.5-1.5 mm. in diameter, the center cinereous to whitish, bordered by a wide, dark red, indefinite, unraised margin, the entire spot occasionally dehiscent. Fasciculae few, gregarious in the center of the spot, spreading, of few hyphae, arising from a well-developed, subcuticular stroma  $13-15 \mu$  wide. Conidiophores lax, spreading, multiseptate, geniculate throughout their distal third, olivaceous to brown,  $50-80 \times 4 \mu$ . Spores hyaline, acicular, 10-12 septate,  $100-150 \times 3.5 \mu$ .

On leaves of *Mentha canadensis*.

Vandalia, Fayette County, Illinois, July 14, 1924. Acc. No. 13699 (type); Goreville, Johnson County, June 22, 1924. Acc. No. 8199.

A certain similarity of aspect is evident between the conidiophores of this species and those of *C. Nepetae*, which is parasitic upon *Nepeta cataria*, another mint. In both cases they arise from a stromatic cluster of hyphal cells and are abundantly geniculate throughout their distal portions. Our species is especially distinguished, however, by the unusual development of the stroma, the small number (4 or 5) of hyphae in a fascicle, their laxness, and the more limited range of spore length.

***Cercospora Paeoniae* Tehon & Daniels, n. sp.**

Spots circular or subcircular, 2-10 mm. in diameter, tan when young, brown when old and then marked with numerous concentric rings caused by the collapse of internal tissue and folding of the epidermis; margin indefinite. Fasciculae small, abundant, scattered, lax; basal tubercle not prominent. Conidiophores brown, undulating, geniculate toward the apex, 4-7 septate,  $20-60 \times 2-4 \mu$ ; basal cell distended and spherical. Spores hyaline, cylindrical or slightly obclavate, definitely falcate, 10-15 septate,  $45-60 \times 2-3 \mu$ ; geniscar not marked.

On leaves of *Paeonia officinalis*.

Prairie du Rocher, Randolph County, Illinois, August 24, 1922. Acc. No. 5645 (type).

This differs distinctly from *C. variicolor* Wint., which also occurs on *Paeonia*, in the length and septation of its conidiophores, and in the color, size and septation of the spores, as well as in the tubercle which, in our species, is never prominent but may often be nearly absent.

***Cercospora Rhapontici* Tehon & Daniels, n. sp.**

Spots circular or subcircular, 2-4 mm. in diameter, centers grayish, margins brown and definite. Fasciculae amphigenous but more abundant above, scattered, lax, ascending, of 4 to 12 hyphae and from a small stromatic base. Conidiophores fuliginous to olivaceous, nearly straight, 2-4 septate below the geniscars which are usually several, prominently marked, and considerably separated, 60-75 x 5.5-6  $\mu$ . Spores long, cylindrical or cylindrical-obclavate, hyaline, 4-15 septate, 100-150 x 3-4  $\mu$ . (PLATE 25, FIG. 11).

On leaves of *Rheum Rhaponticum*.

Coxeyville, Monroe County, Illinois, August 24, 1922. Acc. No. 5111 (type).

There is no agreement between this species and *C. Rhei* Grog. reported in Europe on *Rheum officinale*, exsiccati specimens of which we have had for comparison.

***Cercospora Zeae-maydis* Tehon & Daniels, n. sp.**

Spots brown or tan, evident above and below,  $\frac{1}{2}$  x 1-2 cm., or confluent and then much more extensive, not limited or bordered. Fasciculae amphigenous, abundant, scattered, low, spreading, long-oval, arising from nearly closed stomata. Conidiophores lax but ascending, 3-8 septate, olivaceous to brown, bearing a single apical geniscar, 70-90 x 4  $\mu$ . Spores hyaline, distinctly obclavate, 4-10 septate, 50-85 x 5-9  $\mu$ .

On leaves of *Zea Mays*. (PLATE 25, FIG. 12.)

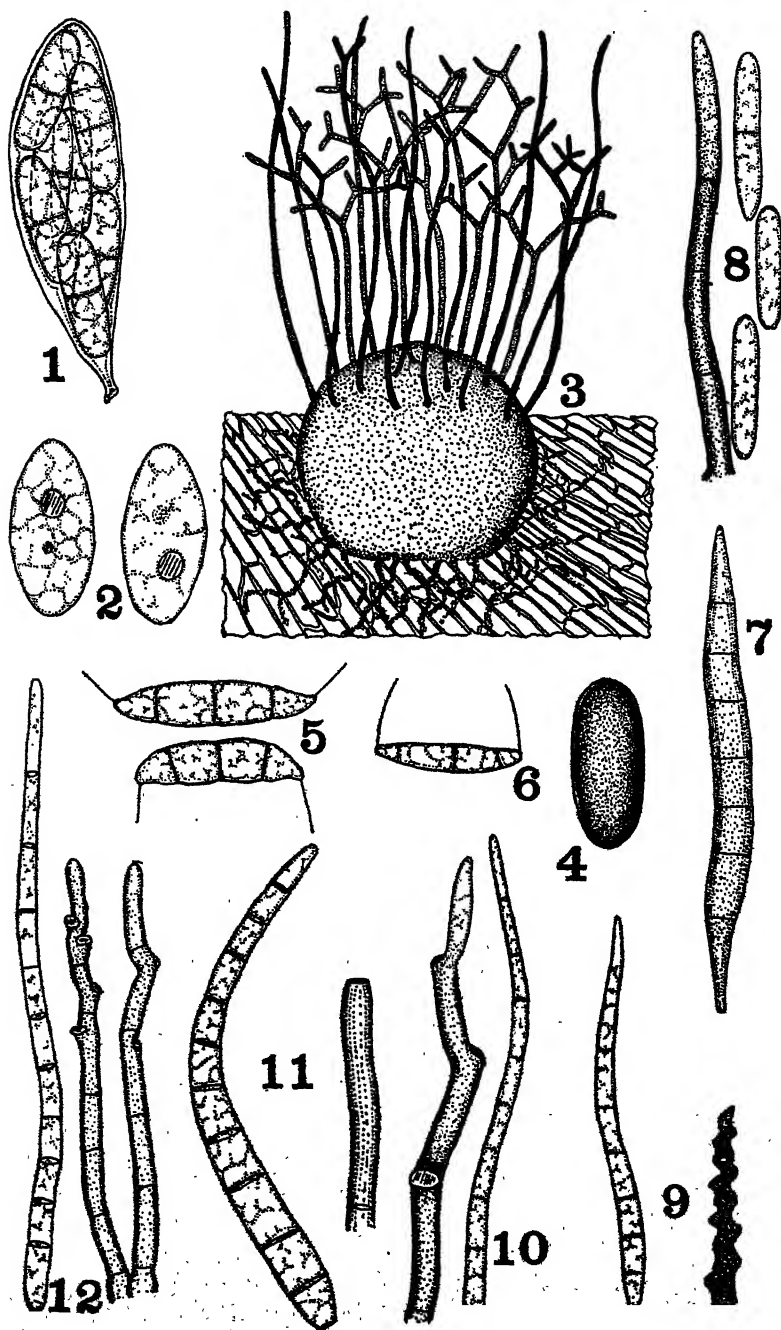
McClure, Alexander County, Illinois, August 29, 1924. Acc. No. 4276 (type).

Aside from the fact that this appears to be the first record of a *Cercospora* on corn, the fungus is distinctive as well in its conidiophores, which bear a single apical spore scar, suggesting that they are single-spored only. We have not seen, in our collection, a single instance of multi-geniculation in this species—a condition which appears, in our experience, to be generally rare in the genus.

ILLINOIS STATE NATURAL HISTORY SURVEY,  
URBANA, ILLINOIS







PARASITIC FUNGI

EXPLANATION OF PLATE 25

- Fig. 1. Ascus of *Mycosphaerella cornicola*.
- Fig. 2. Spores of *Phyllosticta Allii*.
- Fig. 3. Pycnidium of *Chaetomella Triticum*.
- Fig. 4. Spore of *Sphaeropsis Negundinis*.
- Fig. 5. Spores of *Cryptostictis Paeoniae*.
- Fig. 6. Spore of *Cryptostictis Violae*.
- Fig. 7. Spore of *Phaeoseptoria Caricis*.
- Fig. 8. Conidiophore and spores of *Cercospora Abutilonis*.
- Fig. 9. Conidiophore tip and spore of *Cercospora Decodonis*.
- Fig. 10. Conidiophores and spore of *Cercospora menthicola*.
- Fig. 11. Conidiophore tip and spore of *Cercospora Rhapontici*.
- Fig. 12. Conidiophore tip and spore of *Cercospora Zeae-maydis*.

## FIVE NEW HYPOGAEOUS FUNGI

HELEN M. GILKEY

(WITH PLATE 26)

### *Tuber giganteum* sp. nov.

Ascocarp light yellowish-gray, with wide white venae externae conspicuous on surface, 1.8–5.5 cm. in diameter, sub-globose, much convoluted; surface very minutely scabrous; gleba light chocolate colored at maturity, marbled with distinct shining white veins varying in width, older specimens containing several large fissures from breaking along venae externae; venae externae rarely converging at a distinct point; outer layer of cortex pseudoparenchymatous, changing to loose hyphal tissue which gradually merges into sub-cortical layer of more slender hyphae; thickness from the surface to the hymenium 220–260  $\mu$ ; venae internae and hymenial tissue similar to structure of the sub-cortex; venae externae of loosely arranged hyphae, breaking away at maturity to form fissures; asci not stipitate, semi-globose, 52–70 x 74–80  $\mu$ , 1–4- (rarely 5-) spored; spores dark yellowish-brown, ellipsoid or ovoid, 17–39 x 35–52  $\mu$ , alveolate, 5–9 x 7–10 alveoli across the diameters, these varying somewhat in size on a single spore; also apparently very minute alveoli on inner surface of epispore; sculpturing 2–3  $\mu$  in height. (PLATE 26, FIG. 1.)

Collected in clay soil under trees and shrubs, by John Sert, at Bandon, Oregon, May 2, 1921.

This is, to my knowledge, the largest *Tuber* reported from the United States, several specimens of the collection reaching 5.5 cm. in diameter. Mr. Sert discovered the fruiting bodies from several inches to a foot deep in a clay hillside which was being graded for a road bed. The spores are long-ellipsoid like those of *Tuber gibbosum* Hark., but are rounded rather than pointed at the ends and are generally smaller. The ascocarp of *T. gibbosum* is cinnamon-brown rather than yellowish-gray; the surface is covered with knotty hairs which are absent in the above described species; and the inner surface of the epispore does not show the secondary sculpturing described above.

***Tuber longisporum* sp. nov.**

Ascocarp purplish-brown (in material preserved in alcohol), slightly lobed, 1-1.5 cm. in diameter; surface somewhat coarsely verrucose; gleba brown (in preserved material); cortex coarsely and regularly pseudoparenchymatous, light brown in color for 100  $\mu$  or more inward from bases of verrucosities, changing rather abruptly to sub-cortex of whitish, coarse, compactly arranged, more or less united hyphae; thickness of complete peridium below base of papillae 200  $\mu$  or sometimes more; papillae approximately 100  $\mu$  high; venae externae filled with loose hyphae which sometimes break away in older ascocarps leaving wide hollow canals in the ascocarp; venae internae and tissue between asci continuing from sub-cortex and composed of somewhat closely associated but unconnected and coarse hyphae; asci fragile, 66-76  $\mu$ , 1-4-spored; spores yellow, mostly long-ellipsoid, generally somewhat pointed at both ends, 20-32.5 x 27-45  $\mu$ , coarsely alveolate, 3-5 x 4-7 alveoli across diameters; minute alveoli apparent on inner surface of epispore. (PLATE 26, FIG. 2.)

Collected in McGowan's Woods, Ithaca, N. Y., H. H. Whetzel, July 20, 1903. Herbarium Cornell University, No. 1712.

This species differs from *Tuber Gardnerii* Gilkey (which it most closely resembles in surface markings, color and spore size) in being less convolute, having the spores generally more pointed at both ends (the shape varies somewhat in different specimens) and with coarser and generally fewer alveoli. It differs from *T. gibbosum* Hark. which it resembles in shape of spores, in the surface of the ascocarp which in this species is decidedly verrucose while in *T. gibbosum* Hark. it is only minutely scabrous; in inconspicuous depressions not filled with hairs; and in commonly smaller spores.

***Tuber bisporum* sp. nov.**

Ascocarp brick-red, 2 cm. in diameter, subglobose with a few large lobes; surface verrucose; gleba light colored, becoming dusky as the spores mature; veins white, conspicuous; outer portion of the cortex through the papillae pseudoparenchymatous, remainder of the cortex composed of compactly interwoven fibers, more loosely arranged toward the hymenium; thickness of the peridium 400-800  $\mu$ ; peridium easily separable from the gleba at maturity; tissue between the asci like the tissue of the cortex; venae externae filled with loosely arranged coarse hyphae; asci generally very short-stipitate, globose to ellipsoid, occasionally

pyriform, 90–128  $\mu$ , generally 2- (rarely 1- or 3-) spored; spores dark brown, globose to globose-ellipsoid, 42–57  $\times$  48–62  $\mu$ , coarsely alveolate, the alveoli 4–7  $\times$  5–8 across the diameters; sculpturing 3–4  $\mu$  in height; minute alveoli apparent on inner surface of epispore. (PLATE 26, FIG. 3.)

Collected in a closely wooded hillside ravine, Six Mile Gorge, near Ithaca, New York, August 26, 1924, by Professor J. H. Miller. Herbarium, Cornell University, No. 12690.

This species is closely related to *Tuber irradians* Gilkey, but differs from it in color of the ascocarp in the presence of pseudoparenchyma only in the papillae, in the absence of radial rows of cells in the cortex, in larger spores, and in the presence of minute alveoli on the inner surface of the epispore.

#### ***Choeromyces ellipsosporus* sp. nov.**

Ascocarp silvery white when young, becoming yellowish at maturity, 1–1.5 cm. in diameter, irregular in shape, sometimes elongated, variously lobed, surface minutely scabrous; young ascocarps provided with one or more rhizomorphs which shrivel and disappear at maturity; cortex 200–250  $\mu$  thick, formed of coarse hyphae which coalesce more or less uniformly to form pseudoparenchyma; cortical tissue continuous with that of gleba in which both pseudoparenchyma and separate hyphae appear, the cells becoming 100  $\mu$  in diameter; gleba yellowish, traversed by winding hyphae-filled canals lined with hymenium, these surrounded by a layer of closely interwoven hyphae which become loosely arranged midway between the canals to form irregular winding passageways filled with coarse hyphae and opening to the surface of the ascocarp in fissures; asci very delicate and easily ruptured at maturity, clavate, stipitate, 8-spored, 22.5  $\times$  75–100  $\mu$ ; spores generally 1- or irregularly 2-seriate, slightly yellowish, globose-ellipsoid, 10–11  $\times$  12.5–13.5  $\mu$ , containing one large oil globule; surface of spore covered with minute low papillae, some of which anastomose. (PLATE 26, FIG. 4.)

All previously known species of *Choeromyces* are described with globose spores. Since in all principal points, however, the fungus here described answers to the description of *Chaeromyces*, it has been placed under that genus, the difference in spore shape, also in size of spores and asci, sculpturing, and minor differences in ascocarp character, distinguishing it as a new species.

Collected by H. E. Parks in soil under leaf mold. Santa Clara County, California. No. 1235.

**BARSSIA** gen. nov.

Ascocarp scabrous to verrucose, reddish-yellow, nearly even to lobed, somewhat flattened with an irregular opening at the apex into a central depression; cortical structure of the surface of the ascocarp carried into the depression except where the hymenium projects into it; inner tissue of the ascocarp thrown up in more or less connected folds, forming canals and chambers lined with hymenium, these canals opening into the cavity of the ascocarp; hymenium composed of regularly arranged asci and paraphyses; paraphyses very slender and much longer than the asci; asci cylindrical, somewhat club-shaped, 8-spored; spores ellipsoid, smooth, 1- or incompletely 2-seriate, colorless.

The new genus of Tuberaceae proposed above is for the purpose of accommodating a fungus which has twice been collected this season in considerable numbers. Both immature and mature specimens have been found. It differs from *Genea* which it superficially resembles in having the characteristic hollow chamber formed rather as a depression of the surface than as an internal cavity. This depression is lined with cortex, as is the cavity in *Genea*, but in *Genea* it is a secondary cortex developed from the extended paraphyses, while in the former genus it has no relationship to paraphyses. *Genea* also has sculptured spores while in this fungus the spores are smooth and hyaline. The new fungus differs from *Pseudobalsamia* in having unconnected canals and chambers, definite apical depression, no evidence of a mycelial tuft at the base, and in the possession of a regular hymenium consisting of mostly cylindrical asci and paraphyses. It somewhat resembles *Pachyphloeus*, but resemblance ceases in the character of the depression and its relation to the hymenium, also in the appearance of the spores. *Stephensia* has a basal instead of an apical opening, the cavity opens directly to the hymenium as in *Pachyphloeus*, and the spores are globose. *Hydnotrya* has sculptured spores and no definite cavity into which the venae externae open. The spores of the new fungus resemble those of *Hydnocystis* and *Geopora*, but the distinct venae externae opening to the surface through the cortex of the depression clearly place it with the Tuberaceae rather than the Balsamiaceae to which *Hydnocystis* and *Geopora* belong.

The generic name is given in honor of its discoverer, Professor H. P. Barss, head of the department of Botany and Plant Pathology, Oregon State College.

*Barssia oregonensis* sp. nov.

Ascocarp reddish-yellow, 1–2.5 cm. in diameter, somewhat lobed, more or less flattened, with an apical depression forming an irregular cavity within the ascocarp; surface scabrous to verrucose; cortex mostly consisting of coarse hyphae, these sometimes uniting near the surface to form irregular pseudoparenchyma, swollen tips of the hyphae sometimes projecting from the surface as in *Hydnотryopsis*; gleba penetrated by empty unconnected chambers and canals with hymenium-covered walls, opening into the depression of the ascocarp; hymenium consisting of regularly arranged asci and paraphyses; asci mostly cylindrical, sometimes slightly club-shaped,  $20\text{--}30 \times 170 \mu$ ; paraphyses very slender, not swollen at the tips, extending  $40\text{--}50 \mu$  beyond the tips of the asci; spores smooth, hyaline, ellipsoid,  $15 \times 26 \mu$ . (PLATE 26, FIGS. 5, 6.)

In earth one to three inches deep under leaf mold beneath tree of *Cascara sagrada*, Benton County, Oregon, H. P. Barss, No. 4833, Apr. 12, 1925; same locality, H. P. Barss, No. 4834, Apr. 26, 1925. O. A. C. Mycological Herbarium.

No mycelial attachment was found in any collection of these plants, but the opening into the cavity of the ascocarp was constantly discovered upon the upper side of the fruiting body as it occurred in the soil. Occasionally this opening was extended down one side. It is hoped that with future collections of specimens which are younger than those known at present, the relationship of this fungus with *Pachyphloeus* and *Stephensia*, whose cavity opens directly to the hymenium, may be learned.

CORVALLIS, OREGON

EXPLANATION OF PLATE 26

Fig. 1. *Tuber giganteum*. Spore,  $\times 750$  diameters.

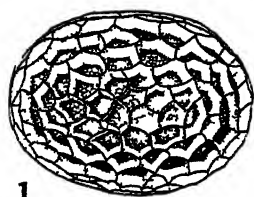
Fig. 2. *Tuber longisporum*. Spore,  $\times 750$  diameters.

Fig. 3. *Tuber bisporum*. Spore,  $\times 550$  diameters.

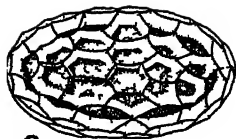
Fig. 4. *Choeromyces ellipsosporus*. Spore,  $\times 1500$  diameters.

Fig. 5. *Barssia oregonensis*. Longitudinal section through ascocarp, showing depression lined with cortex, into which canals open.  $\times 3$  diameters.

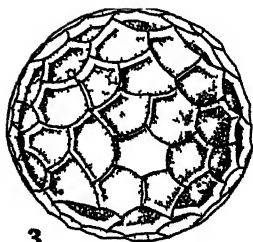
Fig. 6. *Barssia oregonensis*. Portion of hymenium showing asci, spores, and paraphyses,  $\times 380$ .



1



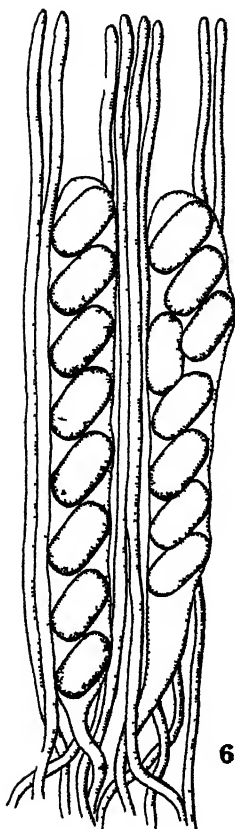
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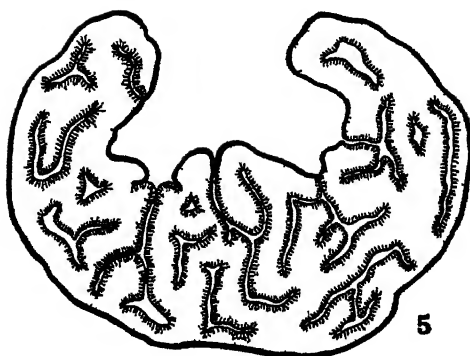
3



4



6



5





# RUSTS OF BRITISH GUIANA AND TRINIDAD

H. SYDOW

(WITH 1 TEXT FIGURE)

The rusts herewith reported were collected by Professor F. L. Stevens, University of Illinois, during the summer of 1922 in British Guiana and Trinidad, and were referred by him to me for determination.

Although the collection is not large, yet it seems to be of some interest, as the Uredineae of the regions mentioned are but poorly known up to date. I suppose that the region is not rich in representatives of this family.

COLEOSPORIUM Lév. Ann. Sci. Nat. III. 8: 373. 1847

COLEOSPORIUM IPOMOEAE (Schw.) Burr. Bull. Ill. Lab. Nat. Hist. 2: 217. 1885.

On *Ipomoea glabra*, British Guiana: Tumatumari, 7-8-1922, No. 56.

MILESINA P. Magn. Berichte Deutsch. Bot. Ges. 27: 325. 1909

**Milesina Lygodii** Sydow, n. sp.

Uredosori hypophylli, maculis decoloratis, irregularibus insidentes, sparsi vel hinc inde pauci aggregati, minutissimi, rotundati, 0.1-0.14 mm. diam., flavi vel flavo-brunneoli, peridio superne ex cellulis irregulariter polygonalibus composito cincti; uredosporae ovatae, ellipsoideo-ovatae vel piriformes, laxiuscule aculeate, hyalinae, 24-26 x 18-25  $\mu$ , membrana 1.5  $\mu$  crassa; teleutosporae non visae.

On *Lygodium* sp., British Guiana: Tumatumari, 7-11-1922, No. 154.

CROSSOPSORA Sydow, Ann. Myc. 16: 243. 1918

**Crossopsora Stevensii** Sydow, n. sp.

Uredosori hypophylli, maculis flavidis vel confluenso majoribus et irregularibus insidentes, sparsi vel saepius plures laxe gregarii,

minuti, punctiformes, ferrugineo-brunnei, vel flavo-brunnei, paraphysibus numerosis basi coalitis rectis vel parum introrsum curvatis subhyalinis vel pallidis, 40–70  $\mu$  longis 7–12  $\mu$  latis, tenuiter (1–1.5  $\mu$ ) tunicatis vel ad apicem crassius tunicatis cincti; uredosporae ovatae vel ellipsoideae, aculeatae, subhyalinae usque pallide brunneolae, 25–36 x 19–25  $\mu$ , membrana 1–1.5  $\mu$  crassa, poris germ. obscuris; teleutosori hypophylli, e centro sororum uredosporiferorum oriundi, filiformes, 1–1.5 mm. longi, 45–70  $\mu$  crassi, recti vel curvati, obscure brunnei; teleutosporae firme conjunctae, ellipsoideae usque elongatae, plerumque utrinque attenuatae, leves, ferrugineae, 35–55 x 16–20  $\mu$ , continuatae, episporio 1  $\mu$  crasso.

On species of Asclepiadaceae, British Guiana: Rockstone, 7–17–1922, Nos. 490 and 491.

On *Echites tomentosa*, Trinidad: Cumuto, 8–16–1922, No. 933.

KUEHNEOLA P. Magn. Bot. Centralblatt 74: 169. 1898

KUEHNEOLA GOSSYPHII (Lagerh.) Arth. N. Am. Fl. 7: 187. 1907.

On cultivated cotton, British Guiana: Georgetown, 7–4–1922, No. 20.

ERIOSPORANGIUM Bert.; Lév. Ann. Sci. Nat. III. 5: 269. 1846

ERIOSPORANGIUM HYPTIDIS (Curt.) Arth. N. Am. Fl. 7: 211. 1912.

On species of Labiatae, British Guiana: Tumatumari, 7–11–1922, No. 179.

ENDOPHYLLUM Lév. Mem. Soc. Linn. Paris 4: 208. 1825

ENDOPHYLLUM GUTTATUM (Kunze) Sydow, Ann. Myc. 18: 179. 1920.

On *Cissus sicyoides* L., British Guiana: Coverden, 8–4–1922, Nos. 738, 745. Trinidad: Cumuto, 8–16–1922, No. 901.

ENDOPHYLLUM PUMILIO (Kunze) Sydow, Ann. Myc. 18: 179. 1920.

On *Clibadium* sp., British Guiana: Coverden, 8–4–1922, No. 737; 8–5–1922, No. 754.

ENDOPHYLLOIDES Whetzel & Olive, Am. Jour. Bot. 4: 50. 1917

ENDOPHYLLOIDES PORTORICENSIS Whetzel & Olive, Am. Jour. Bot. 4: 51. 1917.

On *Mikania* sp., British Guiana: Coverden, 8-5-1922, No. 756.

MARAVALLIA Arth. Bot. Gaz. 73: 60. 1922

**Maravalia** *Ingae* Sydow, n. sp.

Teleutosori hypophylli, maculis flavis vel flavo-brunneolis 0.5-1.5 cm. diam., insidentes, plus minus copiose in quaque macula evoluti, punctiformes, pulvinati, ca 0.2 mm. diam., mox nudi, primo flavo-brunnei, dein ob germinationem albi et velutini; teleutosporeae clavatae, elongato-oblongae vel cylindraceae, ad apicem rotundatae, ad basim plerumque attenuatae, hyalinae, leves, 60-90 x 15-20  $\mu$ , episporio ca 0.5  $\mu$  crasso, statim germinantes; pedicello hyalino, longiusculo, 8-10  $\mu$  crasso; sporidia globulosa, 8-10  $\mu$  diam.

On *Inga* sp., British Guiana: Vreedn Hoor, 8-1-1922, No. 715. Type. Trinidad: Coverden, 8-8-1922, No. 790.

The genus *Maravalia* has been established by Arthur and Thaxter with one species, *M. pallida*, growing on *Pithecellobium latifolium* in Trinidad. The new species from Guiana is certainly very closely related to the type species, and one might even believe that both are identical, but I prefer to keep them distinct as they live on different host genera. Judging from the description of the type species which I have not yet seen, the Guiana fungus differs only slightly by smaller, less confluent sori and somewhat larger spores.

A third member of the genus is *Uromyces albescens* Syd., described in Ann. Myc. 14: 66, 1916, on *Pithecellobium glomeratum* from Peruvia. It now becomes *Maravalia albescens* Syd.; it seems to differ in the smaller spores.

UROMYCES Link, Ges. Nat. Freunde Berlin Mag. 7: 28. 1816

UROMYCES COLUMBIANUS Mayor, Mém. Soc. Neuch. 5: 467. 1913.

On *Melanthera* sp., Trinidad: St. Clair, 8-15-1922, No. 886.

UROMYCES DOLICHOLI Arth. Bull. Torrey Club 33: 27. 1906.

On *Cajan cajan*, Trinidad: Port of Spain, 8-14-1922, No. 869.

UROMYCES LEPTODERMUS Sydow; Sydow & Butler, Ann. Myc. 4: 430. 1906.

On *Lasiacis sorghoidea*, Trinidad: St. Clair, 8-15-1922, No. 887.

On *Panicum barbinode*, British Guiana: Georgetown, Lemada Canal, 8-2-1922, No. 717.

UROMYCES PROËMINENS (DC.) Pass. Rab. Fungi Eur. 1795. 1873.

On *Chamaesyce* sp., Trinidad: Port of Spain, 8-14-1922, No. 859.

UROMYCES SCLERIAE P. Henn. Hedwigia Beibl. 38: 67. 1899.

On *Scleria melaleuca*, British Guiana: Kartabo, 7-23-1922, No. 616; Kartabo, 7-21-1922, No. 507. Trinidad: Cumuto, 8-16-1922, No. 905; St. Augustine, 8-13-1922, No. 840.

UROMYCES WULFFIAE-STENOGLOSSAE Diet. Ann. Myc. 6: 96. 1908.

On *Wulffia baccata*, British Guiana, Demerara-Essequibo R. Ry., 7-15-1922, No. 343; Wismar, 7-14-1922, No. 282; Demerara-Essequibo R. Ry., 7-15-1922, No. 396; Georgetown, Lemada Canal, 8-2-1922, No. 713. Trinidad: St. Clair, 8-15-1922, No. 885.

PUCCINIA Pers. Tent. Disp. Fung. 38. 1797

PUCCINIA ANTICQUIENSIS Mayor, Mém. Soc. Neuch. Sci. Nat. 5: 743. 1913.

On *Cyperus diffusus*, British Guiana: Tumatumari, 7-10-1922, No. 137.

PUCCINIA ARECHAVALETAE Speg. Ann. Soc. Ci. Arg. 12: 67. 1881.

On *Cardiospermum* sp., British Guiana: Coverden, 8-4-1922, No. 734.

PUCCINIA CANALICULATA (Schw.) Lagh. Ured. Herb. El. Fries 51. 1894.

On *Cyperus* sp., British Guiana.

PUCCINIA CANNAE (Wint.) P. Henn. Hedwigia 41: 105. 1902.

On *Canna* sp., British Guiana: Peters Hall, 7-5-1922, No. 26; Kartabo, 7-21-1922, No. 511; 7-2-1922, No. 12. Trinidad: Port of Spain, 6-28-1922, No. 4; Port of Spain, 8-14-1922, No. 867.

PUCCINIA CENCHRI Diet. & Holw. Bot. Gaz. 24: 28. 1897.

On *Cenchrus echinatus*, British Guiana: Georgetown, 7-2-1922, No. 9.

PUCCINIA ELEUTHERANTHERAE Diet. Ann. Myc 7: 354. 1909.

On *Eleutheranthera ruderalis*, British Guiana: Georgetown, 7-2-1922, No. 13. Trinidad: St. Augustine, 8-13-1922, No. 823.

PUCCINIA EMILIAE P. Henn. Hedwigia 37: 278. 1898.

On *Emilia coccinea*, Trinidad: Port of Spain, 8-14-1922, No. 874.

PUCCINIA GYMNOPOGONIS Sydow, Monogr. Ured. 1: 755. 1904.

On *Gymnopogon foliosus*, British Guiana: Demerara-Essequibo R. Ry., 7-15-1922, No. 405.

PUCCINIA GOUANIAE Holw. Ann. Myc. 3: 21. 1905. (Pycnia and primary uredinia.)

On *Gouania* sp., British Guiana: Rockstone, 7-13-1922, No. 251.

PUCCINIA IGNAVA (Arth.) Arth. Mycologia 14: 17. 1922.

On *Bambusa* sp., British Guiana: Rockstone, 7-17-1922, No. 447; Coverden, 8-4-1922, No. 720.

PUCCINIA SEAVERIANA Arth. Mycologia 14: 18. 1922.

On *Oliganthes condensatus*, Trinidad: St. Clair, 8-15-1922, No. 888.

PUCCINIA TUBULOSA (Pat. & Gail.) Arth. Am. Jour. Bot. 5: 464. 1918.

*Uredo paspalicola* P. Henn. Hedwigia 44: 57. 1905.

On *Paspalum conjugatum*, British Guiana: Peters Hall, 7-5-1922, No. 25.

On *Paspalum virgatum*, British Guiana: Georgetown, 7-2-1922, No 17; Tumatumari, 7-8-1922, No. 31.

PUCCINIA URBANIANA P. Henn. Hedwigia 37: 278. 1898.

On *Stachytarpheta* sp., British Guiana: Tumatumari, 7-10-1922, No. 131.

DASYSPORA Berk. & Curt. Jour. Acad. Phila. 2: 281. 1853

DASYSPORA GREGARIA (Kunze) P. Henn. Hedwigia 35: 231. 1896.

*Dasympora foveolata* Berk. & Curt. Jour. Acad. Phila. 2: 281. 1853.

On Anonaceae sp.?, British Guiana: Kartabo, 7-23-1922, No. 589.

This collection is exceedingly interesting because it bears the pycnidial and uredo stages of this remarkable fungus. The latter stage is quite peculiar and entirely different from the ordinary uredospores of the Uredineae.

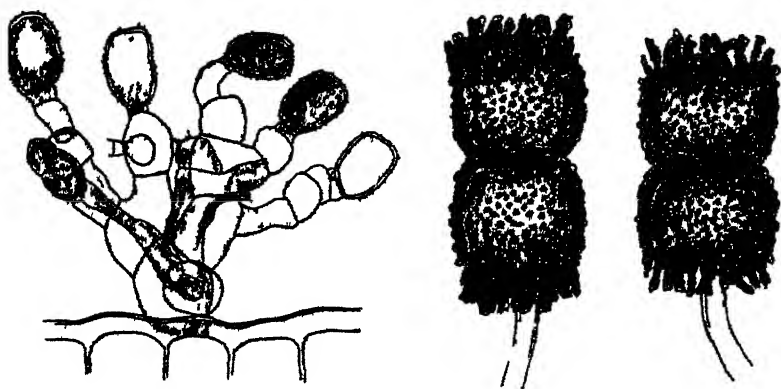


FIG. 1. *Dasympora gregaria*

The pycnia, more or less numerous, occur on the upper side of the leaves in circular groups of about 4-6 mm. in diameter. They are flattened, conical, black bodies, originating beneath the epidermis and measuring about 120-160  $\mu$  in breadth and 80-100  $\mu$  in height.

The uredosori are either epiphyllous together with pycnia, or

more numerous on the lower side. They represent very small, but densely crowded tufts, consisting of more or less numerous hyphae. Unfortunately the material placed at my disposal being only scanty I could not make out with certainty whether the hyphae originate beneath the cuticle or beneath the epidermis although I think the latter is the case. Either one hypha alone or a few fascicled ones are seen to break through the epidermis (or cuticle?). The primary hypha, first consisting of two or three large cells only, soon branches; the primary branches soon form new outgrowths which often branch again in turn, hence at last tufts of many spreading branched hyphae are formed. Even when the primary hypha is very short and consists of only two cells it forms a single uredospore at its tip. The spore grows rapidly and when mature falls off. Now the apical hyphal cell grows on and forms a new cell which gives rise to a new uredospore and so on in the same manner the branches continue growing and forming new uredospores on the top of each cell. The longest hyphae observed measured up to  $250\ \mu$  in length, consisting of about ten cells. The cells are irregular in shape and size, the basal cells being ordinarily the largest ones, while the upper cells are the smallest. They measure up to  $25\ \mu$  in length and  $14\text{--}18\ \mu$  in breadth.

The thin-walled uredospores are uniformly ellipsoidal, with yellow contents. The hyaline membrane is only  $1\ \mu$  thick and densely and minutely verrucose. The spores measure  $22\text{--}24\ \mu$  in length and  $16\text{--}18\ \mu$  in breadth. The germ pores are obscure.

The peculiar structure of the uredo stage is best seen from the accompanying figure. This represents a small tuft only, also two teleutospores.

If I am correctly informed the uredo stage has been mentioned only once<sup>1</sup> but I am unable to find that any description has been published up to date.

AECIDIUM Pers. in J. F. Gmel. Syst. Nat. 2: 1472. 1791  
AECIDIUM ALIBERTIAE Arth. Mycologia 14: 21. 1922.

On *Alibertia* sp., Trinidad: Cumuto, 8-16-1922, Nos. 931, 957, 965.

<sup>1</sup> See Bull. Torrey Club 48: 39. 1921.



AECIDIUM CORDIAE P. Henn. Bot. Jahrb. 17: 491. 1893.

On *Cordia cylindrostachya*, Trinidad: St. Clair, 8-15-1922, No. 892.

The specimens agree entirely with the type of *Aecidium Cordiae* P. Henn., as the spores are coarsely verrucose, and the membrane much thickened at the apex. *Aecidium brasiliense* Diet., which according to Arthur grows on the same host (*Cordia cylindrostachya*) in Trinidad, differs by the much smaller, less verrucose, not thickened spores.

AECIDIUM RIONEGRENSE P. Henn. Hedwigia 43: 166. 1904.

On species of Anonaceae, British Guiana: Wismar, 7-14-1922, No. 273; Demerara-Essequibo R. Ry., 7-15-1922, No. 355; Penal Settlement, 7-25-1922, No. 681.

UREDIO Pers. Ann. Bot. Usteri 15: 16. 1795

UREDIO ARTOCARPI Berk. & Br. Jour. Linn. Soc. 14: 93. 1873.

On species of Moraceae (breadfruit), British Guiana: Tumatumari, 7-11-1922, No. 185.

UREDIO CYRTOPODII Sydow, Bull. Herb. Boissier 1: 77. 1907.

On *Cyrtopodium* sp., British Guiana: Demerara-Essequibo R. Ry., 7-15-1922, No. 395.

Compared with the type specimen from Brazil and found to agree in every respect.

UREDIO DIOSCOREAE P. Henn. Hedwigia 42: (108). 1903.

On *Dioscorea* sp., British Guiana: Tumatumari, 7-9-1922, No. 91.

UREDIO IGNOBILIS Sydow, Ann. Myc. 4: 444. 1906.

On *Sporobolus indicus*, British Guiana: Georgetown, 7-2-1922, No. 15.

BERLIN-SCHÖNEBERG,  
GERMANY.

## NOTES AND BRIEF ARTICLES

Dr. F. D. Kern, of Pennsylvania State College, has been granted a year's leave of absence and will assume the duties of Dean of the College of Agriculture of Porto Rico, Mayaguez. Dr. Kern and family will take up their residence in Porto Rico for one year.

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"Plant Disease Fungi" is the title of a new book by F. L. Stevens. It is a revision and a condensation of his former work, "The Fungi Which Cause Plant Disease." The book comprises 468 pages of text and 407 illustrations, and will be much used by plant pathologists as a guide in determining the organism responsible for the many diseases of cultivated plants.

During a recent visit to Cornell University the writer had the privilege of looking over the Durand collection of Discomycetes, purchased by the university. The collection is kept together as a unit by itself and in a separate room. It consists of preserved plants, microscopic slides, and a very extensive set of notes. It is probably the most complete collection of Discomycetes in America. As a student of this particular group it is my intention to spend considerable time in the near future working over this material preparatory to a monograph of the cup-fungi of North America.—FRED J. SEAYER.

### MYCOLOGICAL FORAY

(WITH 1 TEXT FIGURE)

During the early part of June the New York Botanical Garden joined with Cornell University, Department of Plant Pathology, and the Pennsylvania State College, Department of Botany, in a mycological excursion to Trout Run, Pennsylvania. This is the third "foray" of this nature held by the above institutions. On the former occasions Brooklyn Botanic Garden and Syracuse

University also joined the enterprise. There has been some thought of making this an annual affair to be participated in by the mycologists of a number of the eastern institutions or at least as many as might see fit to join.



FIG. 1. In the Pennsylvania woods

There is much to be gained by such a meeting. It gives the various mycologists a chance to get together and, in an informal way, to talk over the problems of mutual interest. Participated in, as it is, by the teachers and graduate students of the various institutions, it is a source of inspiration to both the teacher and student. Also the amount of material obtained even in a few days by such a company, each with his own special mycological interest, is considerable. The material is divided into sets and one set of specimens turned over to each of the institutions represented. Such a collection not only results in the extension of our knowledge of the range of distribution of the more common species but often adds new or rare fungi to our herbaria.

It was the writer's privilege to attend the most recent expedition June 5-7 at Trout Run, Pennsylvania. Leaving New York on the night train, Thursday, June 4, our train arrived in Ithaca

early Friday morning. There, joined by the Cornell party, after a hurried breakfast we started for a one hundred and twenty mile drive by auto to the place previously selected for the outing where we were to be met by the Pennsylvania State College contingent. The early morning drive through southern New York and northern Pennsylvania over the splendid concrete roads of that section was a very inspiring one. Arriving at our destination about noon we were soon joined by the Pennsylvania party and the remainder of the day was spent in the hills in the immediate vicinity of Trout Run, in the heart of the Pennsylvania mountains.

The following day, Saturday, it was planned to spend the entire day in the woods about seven miles from the village where some of the party were camping, the dinner to be cooked by the campers and partaken of in camp style. Although the weather was excessively hot the fungi seemed to be rather backward probably owing to the unusually cold spring but a creditable number of plants was collected.

Returning to the village in the evening we started on our return trip the next morning, Sunday, stopping at favorable points for continued collecting, reaching Ithaca Sunday afternoon. The following day, Monday, was spent at the University looking over the "plunder" and comparing notes, the return to New York being made by the night train arriving home Tuesday morning.

Suitable labels have been printed and the material is being prepared for distribution and mounting. The accompanying photograph shows those present on the second day of this occasion. Others attended for the first day only.

FRED J. SEAVER

#### MISS LISTER'S "MYCETOZOA"

The third edition of Lister's monograph of the "Mycetozoa" has just appeared. The first edition of this standard work on the slime-moulds appeared in 1894 and represented the results of many years of labor on the part of Mr. Arthur Lister. The drawings many of which were in color were executed by Mr. Lister and his able daughter Miss Gulielma Lister. Mr. Lister died July 19, 1908.

The widespread interest in the first edition resulted in bringing in much new material. As a result of this Miss Lister prepared a second edition, much enlarged and with improvements in the quality of the plates. The second edition appeared in 1911.

The third edition dated January, 1925, includes three additional genera and forty-six new species. Some of the new species are raised from varietal rank. Twenty-two new plates have been added, eight of which are colored.

With the appearance of this and Macbride's second edition of "North American Slime-Moulds" the American student is able to avail himself of the most recent information on this group of organisms.

---

A fine specimen of the fungus commonly known as "tuckahoe" has recently been received from Dr. F. A. Wolf of the North Carolina Agricultural Experiment Station. The specimen is accompanied by the following statement: "I am sending to you under other cover, a large tuckahoe which weighed in the fresh condition,  $4\frac{1}{2}$  lbs. This specimen came into the laboratory on July 2, and a week later had formed a fruit body which you see at one end of the specimen. I have tried to wrap the specimen carefully so that it would reach you in good condition. Some time ago, I promised to send to the New York Botanical Garden for their popular exhibit, a fruiting specimen, in case one came to hand. The one which is being sent to you is much the best one which I have yet developed. It has the additional interest of having been formed on a corn stalk. You can see in the cortical tissues, remnants of the rind of the stalk. You can note, too, that the joint or node occurs at the middle of the tuckahoe."

This specimen is a valuable addition to our mycological exhibit.

# INDEX TO VOLUME XVII

New names and the final members of new combinations are in **bold face type**

- Abies concolor*, 203; *grandis*, 69 75.  
77  
*Abutilon*, 133; *periplocifolium*, 11;  
Theophrasti, 246  
*Acalypha bisetosa*, 144  
*Acer*, 99; *Negundo*, 240, 243, 245;  
*rubrum*, 110; *spicatum*, 106  
*Acnistus arborescens*, 141  
*Actaea*, 79  
*Adenocaulon*, 227; *bicolor*, 228  
*Aecidiella Triumfettae*, 12  
*Aecidium Alibertiae*, 261; *Allenii*, 80,  
82; *brasiliense*, 262; *circumscriptionum*,  
10; *Cissi*, 10; *Cordia*, 262; *Ipo-*  
*moeae-panduranae*, 3; *ronnegrense*,  
262  
*Agaricus alneus*, 16; *Antillarum*, 16;  
*discretus*, 15; *hirtus*, 15; *pediades*,  
16; *peregrinus*, 15; *rhodoxanthus*,  
117; *solidipes*, 14; *striatus*, 15  
*Agoseris*, 150  
*Agropyron*, 79; *caninum*, 203; *da-*  
*systachyum*, 78, 81, 83, 85; *repens*,  
78, 83; *Richardsonii*, 78, 81, 83, 85;  
*Smithii*, 78, 81, 83; *spicatum*, 78,  
81-83, 85; *tenerum*, 78, 80-83, 85  
*Albizzia Lebbeck*, 9  
*Albugo Bliti*, 2; *Ipomoeae-pandu-*  
*ranae*, 2; *Tragopogonis*, 3  
*Aleurodiscus amorphus*, 71; *croceus*,  
71; *helveolus*, 71; *succineus*, 71  
*Alibertia*, 261  
*Allium Cepa*, 242; *Diehl*, 204  
*Alnus*, 99; *tenuifolia*, 68, 69, 70  
*Alopecurus aristulatus*, 79, 81, 82, 83;  
*pratensis*, 79  
*Alphitomorpha communis*, 3  
*Amanita*, 44, 128  
*Amaranthus tristis*, 2  
*Amauroderma*, 72, 73; *flaviporum*, 14  
*Ambrosia trifida*, 42  
*Amelanchier*, 206; *alnifolia*, 84, 86;  
*florida*, 206, 207; *Jonesiana*, 207;  
*polycarpa*, 202, 207; *prunifolia*,  
206; *utahensis*, 207  
*Amianthium*, 152  
*Amygdalus*, 98, 99  
*Andersen*, Emma N., Leva B. Walker  
and, Relation of glycogen to spore-  
ejection, 154  
*Andira inermis*, 8; *jamaicensis*, 8  
*Anemone*, 79; *cylindrica*, 78, 85;  
*globosa*, 78, 85  
*Anthacanthus spinosus*, 13  
*Anthostomella*, 185, 186, 187; *disco-*  
*phora*, 187; *mirabilis*, 188, 189  
*Appendiculella*, 143; *arecibensis*, 144,  
147; *Calophylli*, 144; *calostroma*,  
142; *compositarum*, 144, 147; *tu-*  
*berculata*, 144  
*Aquilegia canadensis*, 241, *flavescens*,  
206, 207  
*Arbutus Menziesii*, 71  
*Arenaria glabrescens*, 208  
*Argomyces insulanus*, 12  
*Armillaria mellea*, 128  
*Artemisia aromatica*, 203; *tridentata*,  
203  
*Arundinaria*, 188  
Ascogenous stage, *Coryneum Ru-*  
*borum* Oud. and its, S. M. Zeller, 33  
*Ascophanus*, 158; *carneus*, 158  
*Ascospora*, 35, 36, 38, 39, 40; *Bei-*  
*jerinckii*, 37, 39, 41; *Ruborum*, 39-  
41  
*Aspergillus*, 221  
*Aster*, 227, 230-232, 234; *conspicuus*,  
231, 233-235; *laevis*, 234; *laevis*  
*Geyeri*, 233, 234; *lateriflorus*, 42;  
*Porteri*, 234  
*Asterina*, 146; *Coccolobae*, 3; *Colu-*  
*brinae*, 3; *coriacea*, 133; *diplo-*  
*carpa*, 132, 134; *dubiosa*, 145;  
*Kernii*, 133, 147; *Sidae*, 132;  
*sidicola*, 132; *solanicola*, 133, 134;  
*triloba*, 134  
*Asteromella astericola*, 42  
*Astrocystis*, The genus, William W.  
*Diehl*, 185  
*Astrocystis mirabilis*, 185, 187-190  
*Atriplex confertifolia*, 208; *rosea*,  
204  
*Auerswaldia Arengae*, 187  
*Aulographum Cestri*, 137  
*Aulospermum longipes*, 204  
*Avena*, 94; *fatua*, 80, 82, 85, 181;  
*nuda*, 163, 164, 166, 168, 176, 180;  
*nuda inermis*, 163, 180; *orientalis*,  
181; *sativa*, 80-83, 85, 163, 165, 180,  
181; *sativa nigra*, 165; *sativa*  
*montana*, 165; *sterilis*, 181  
*Avicennia nitida*, 139

- Baccharis, 98  
 Bambusa, 259; vulgaris, 189  
 Barlaea discoidea, 47; verrucosa, 223  
 Barssia, 253; oregonensis, 254  
 Beckmannia erucaeformis, 80-83  
 Belonidium leucorrhodinum, 48  
 Betula nigra, 42  
 Bisby, G. R., Zonation in cultures of  
   Fusarium discolor sulphureum, 89  
 Bistorta bistortoides, 208  
 Blechnum Blechnum, 11  
 Boletinus, 117  
 Boletus fasciatus, 15; hydroides, 16;  
   nigromarginatus, 14; sanguineus,  
   16; subtomentosus, 117  
 Borreria parviflora, 12  
 Botanizing in Virginia, W. A. Murrill,  
   44  
 Botryodiplodia Gossypii, 192  
 Botryosphaeria and Physalospora in  
   the eastern United States, C. L.  
   Shear, Neil E. Stevens and Mar-  
   guerite S. Wilcox, 98  
 Botryosphaeria fuliginosa, 191-193,  
   196, 197, 200, 201; Ribis, 98-107,  
   194-201; Ribis chromogena, 100,  
   103, 105, 197  
 Boudiera, 223  
 Brassica Pe-tsai, 160  
 Bresadola, G., New species of fungi,  
   68  
 Bromus ciliatus, 78-83, 85; latiglu-  
   mis, 79, 81-83, 85; Porteri, 81-83,  
   85; Pumpellianus, 78-83  
 Brown canker of roses, Anna E.  
   Jenkins, 87  
 Brunellia comocladifolia, 133, 147  
 Cabbage, Club-root of Chinese, W. H.  
   Davis, 160  
 Caeoma confluens, 202  
 Cajan Cajan, 13, 257  
 Calamagrostis canadensis, 80-83, 85;  
   elongata, 80-83; inexpansa, 80, 81,  
   83, 85  
 Callistephus hortensis, 242  
 Calophyllum antillanum, 144; Calaba,  
   144  
 Camelina microcarpa, 204  
 Campanularius solidipes, 14  
 Canella Winterana, 137  
 Canker of roses, Brown, Anna E.  
   Jenkins, 87  
 Canna, 259  
 Capsella Bursa-pastoris, 204  
 Cardiospermum, 258; microcarpum,  
   11  
 Carex, 150, 205, 206, 245; eburnea, 42;  
   festivella, 205; filifolia, 82, 83;  
   illinoensis, 127; tribuloides, 42  
 Cascara sagrada, 254  
 Cascaria sylvestris, 137  
 Catabrosa aquatica, 204  
 Cecropia, 50  
 Celastrus scandens, 105  
 Cenchrus 6, 11; carolinianus, 42;  
   echinatus, 259  
 Cephalothecium, 90, 96; roseum, 91, 94  
 Cercis, 99  
 Cercospora Abutilonis, 246; althaeina,  
   246; Arborescentis, 246; crassoides,  
   42; Decodontis, 246; menthicola,  
   247; Molluginis, 42; Nepetae, 247;  
   Paeoniae, 247; Rhapontici, 248;  
   Rhei, 248; varicolor, 248; Zeae-  
   maydis, 248  
 Ceriomyces Betula, 183  
 Cerenella Ravenelii, 128  
 Cestrum, 133, 137; laurifolium, 134;  
   macrophyllum, 134  
 Chaetomella horrida, 242; Tritici, 242  
 Chaetosphaeria calostroma, 142  
 Chamaesyce, 258  
 Chanterel, 183; cinnabarinus, 184  
 Cheese, The mold associated with the  
   ripening of blue veined, N. S.  
   Golding, 19  
 Chenopodium pratericola, 204  
 Chinese cabbage, Club-root of, W. H.  
   Davis, 160  
 Choeromyces ellipsosporus, 252  
 Chrosperma muscaetoxicum, The life  
   cycle of the rust on fly poison, C. R.  
   Orton and Freeman Weiss, 148  
 Chromosporium pachyderma, 9  
 Chrosperma, 148-152; muscaetoxi-  
   cum, 148, 149, 153  
 Chrysothamnus marianus 205; pu-  
   berulus, 205  
 Ciboria caespitosa, 48  
 Cicinnobolus, 9  
 Cicuta occidentalis, 207  
 Cissampelos Pareira, 6  
 Cissus, 14; sicyoides, 10, 256  
 Citrus, 99, 199, 241  
 Cladosporium caducum, 42  
 Clibadium, 256  
 Clidemia hirta, 142, 145  
 Clitocybe illudens, 129  
 Club-root of Chinese cabbage, W. H.  
   Davis, 160  
 Clypeolum scutelliforme, 139, 147  
 Cocolobis laurifolia, 136; Uvifera, 3  
 Cocos nucifera, 8  
 Coffea arabica, 137  
 Coleosporium, 225; Adenocaulonis,  
   227; arnicale, 228; Asterum, 233;  
   Elephantopodis, 10; Ipomoeae, 10,  
   245; Madae, 227-229; occiden-  
   talis, 227, 234, 235; ribicola, 206,  
   227; Senecionis, 225, 226; Solida-  
   ginis, 226, 227, 231-234, 235;  
   Sonchi, 10; Sonchi-arvensis, 227,  
   236; Tussilaginis, 226

- Coleosporium in the Northwestern United States, The genus, James Robert Weir, 225  
 Collecting around St. Augustine, Florida, W. A. Murrill, 127  
 Colletotrichum atramentarium, 215, 217; *maculans*, 214, 215; *minutum*, 216; *orthosporum*, 216; *Smilacinae*, 245; *solanicolium*, 215; *tabificum*, 217; *Violarum*, 42  
 Colletotrichum v. *Vermicularia*, B. T. Dickson, 213  
 Coltricia cinnamomea, 184  
 Colubrina reclinata, 3  
 Comandra pallida, 206  
 Commelina elegans, 13  
 Coniothyrium *Negundinis*, 243; *olivaceum* var. *Aceris*, 243  
 Convolvulus nodiflorus, 13  
 Cookeina, 46; *tetraspora*, 45  
 Coprinus, 157; *plicatilis*, 15; *stercorarius*, 90  
 Cordia allcococca, 7; *cylindrostachya*, 262; *nitida*, 141  
 Coreopsis, 183  
 Corioloopsis fulvocinerea, 14; *occidentalis*, 14; *rigida*, 14  
 Coriolus, 128; *nigromarginatus*, 14; *pinsitus*, 14  
 Cornus florida, 244; *stolonifera*, 241  
 Corticium apiculatum, 68; *areolatum*, 68; *botryosum*, 69; *confluens*, 69; *consimile*, 68; *deciens*, 68; *furfuraceum*, 69; *laevis*, 68; *lepidum*, 70; *ochraceum*, 70; *scutellare*, 68; *subapiculatum*, 69  
 Cortinarius, 113, 116, 128  
 Coryneum, 37, 41; *Beijerinckii*, 35, 39; *Ruborum*, 33-35, 38-40  
 Coryneum *Ruborum* Oud. and its ascogenous stage, S. M. Zeller, 33  
 Crataegus, 99; *chrysocarpa*, 84; *rivularis*, 207  
 Creonectria ochroleuca, 5  
 Crepis glauca, 209  
 Crescentia cucurbitina, 9  
 Cronartium, 207; *occidentale*, 207; *pyriforme*, 206  
 Crossopora *Stevensii*, 255  
 Crotalaria retusa, 3, 9  
 Croton, 5; *discolor*, 134  
 Cryptostictis *Paeoniae*, 243; *Violae*, 244  
 Cucumis Anguria, 3  
 Cudoniopsis, 210, 211; *pusilla*, 210  
 Culture experiments with heterocyclic rusts in 1922, 1923 and 1924, W. P. Fraser, 78  
 Cultures of *Fusarium discolor* sulphureum, Zonation in, G. R. Bisby, 89  
 Cyathus ambiguus, 17; *Poeppegii*, 17; *vernicosus*, 17  
 Cyperus diffusus, 258  
 Cyrtopodium, 262  
 Cytospora chrysosperma, 218  
 Daedalea amanitoides, 15  
 Daldinia concentrica, 6; *Eschscholzii*, 6  
 Daniels, Eva, L. R. Tehon and, Notes on the parasitic fungi of Illinois—II, 240  
 Daphnopsis caribaea, 140  
 Darluca Filum, 9  
 Dasyscypha calycina, 49; *flavidula*, 49  
 Dasyscypha foveolata, 260; *gregaria*, 260  
 Davis, W. H., Club-root of Chinese cabbage, 160  
 Decodon verticillatus, 247  
 Deschampsia caespitosa, 80-83  
 Diaporthe umbrina, 88  
 Diatrype, 111  
 Dicaeoma hieraciatum, 152  
 Dickson, B. T., *Colletotrichum* v. *Vermicularia*, 213  
 Dictyophora Ravenelii, 109, 112  
 Diehl, William W., The genus *Astrocystis*, 185  
 Dimeromyces, 87  
 Dimorphomyces, 87  
 Diorchidium leve, 12  
 Dioscorea, 262  
 Diospyros, 99; *virginiana*, 105  
 Diplocystis Wrightii, 17  
 Diploia gossypina, 191, 192, 197-201; *natalensis*, 199, 200  
 Diploia gossypina, The life history and relationships of, Neil E. Stevens, 191  
 Distichlis spicata, 83, 85  
 Dolicholus 2, 13  
 Dothidea Crotonis, 5  
 Dothiorella, 99, 107, 194, 197  
 Echites tomentosa, 256  
 Elaeagnus, 79; *commutata*, 80, 81, 85  
 Elephantopus mollis, 10  
 Eleutherantha ruderalis, 259  
 Elfvingiella fasciata, 15  
 Elymus canadensis, 78-81, 83, 85; *curvatus*, 78, 79, 81-83; *diversiglumis*, 78, 81-83; *glaucus*, 203; *innovatus*, 78, 81-83; *Macounii*, 79, 83; *robustus*, 78; *virginicus*, 78, 79  
 Emilia coccinea, 259; *sagittifolia*, 11; *sonchifolia*, 11  
 Endophylloides portoricensis, 257  
 Endophyllum circumscriptum, 10; *guttatum*, 256; *pumilio*, 256  
 Epilobium americanum, 205



- Erinella similis*, 49  
*Eriogonum biumbellatum*, 205; *microthecum*, 205; *racemosum*, 205  
*Eriophorum angustifolium*, 83, 84, 86  
*Eriosporangium Hyptidis*, 256  
*Erysimum repandum*, 204  
*Erysiphe communis*, 3  
*Erythrina glauca*, 145  
*Erythronium grandiflorum parviflorum*, 205  
*Erythroxyton*, 13  
*Eucalyptus*, 98  
*Eudimeromyces*, 87  
*Eugenia proba*, 210; *rhombica*, 5  
*Eupatorium odoratum*, 144  
*Euphorbia robusta*, 209; *pilulifera*, 10; *prostrata*, 13  
*Eutypella Cocos*, 9  
*Exidia glandulosa*, 18  
*Exosporium maculans*, 213, 214; *minutum*, 216  
 Experiments with heteroecious rusts in 1922, 1923 and 1924, Culture, W. P. Fraser, 78  
*Fagus ferruginea*, 75  
 Faris, James A., and George M. Reed, Modes of infection of sorghums by loose kernel smut, 51  
*Festuca elatior*, 78, 82, 83; *viridula*, 81-83  
*Fimetaria fimicola*, 5  
 Five new hypogaeous fungi, Helen M. Gilkey, 250  
*Flammula*, 117, 128; *peregrina*, 15  
 Foray, Mycological, Fred J. Seaver, 263  
 Fraser, W. P., Culture experiments with heteroecious rusts in 1922, 1923 and 1924, 78  
*Froelichia floridana*, 42  
*Fumago vagans*, 9  
 Fungi at Lynchburg, Virginia, W. A. Murrill, 183  
 Fungi, New species of, G. Bresadola, 68  
 Fungous flora of St. Croix, The, Fred J. Seaver, 1  
*Fusarium*, 93; *culmorum*, 97; *discolor sulphureum*, 91, 94-97  
*Fusarium discolor sulphureum*, Zonation in cultures of, G. R. Bisby, 89  
*Ganoderma Curtisii*, 128; *expallens*, 72; *rubeolum*, 73; *subincrustedum*, 15  
 Garrett, A. O., Smuts and rusts of Utah—V, 202  
*Geaster*, 128  
*Genea*, 253  
*Geoglossum nigrum*, 49; *pumilum*, 49  
*Geopora*, 253  
*Gigantochloa Scribneriana*, 189  
 Gilkey, Helen M., Five new hypogaeous fungi, 250  
*Glaux maritima*, 83, 85  
*Gloeocystidium polygonum*, 69; *polygonum var. fulvescens*, 69  
*Gloeophyllum Berkeleyi*, 128; *striatum*, 15  
*Gloeoporus conchoides*, 128  
*Glomium clavispurum*, 4; *simulans*, 4  
 Glycogen to spore-ejection, Relation of, Leva B. Walker and Emma N. Andersen, 154  
*Glycosma occidentalis*, 204  
 Golding, N. S., The mold associated with the ripening of blue veined cheese, 19  
*Gomphidius alabamensis*, 123; *flavipes*, 115, 118, 121, 123; *furcatus*, 114, 115, 119, 123; *glutinosus*, 113-115, 118, 121, 124; *gracilis*, 113, 118, 120, 124; *maculatus*, 113, 114, 118, 119, 121, 124; *nigricans*, 114, 116, 118, 124; *ochraceus*, 114, 118, 119, 122; *oregonensis*, 116, 118, 121, 124; *roseus*, 113, 119, 120, 124; *subroseus*, 114, 118, 120-122; *tomentosus*, 114, 118, 119, 122, 124; *vinicolor*, 114, 119, 125; *viscidus*, 113, 114-116, 118, 122, 123, 125; *viscidus forma columbiana*, 114, 118, 122, 125, 126  
*Gomphidius* in the United States, The genus, C. H. Kauffman, 113  
*Gossypium*, 98, 192; *hirsutum*, 191  
*Gouania*, 259; *polygama*, 12  
*Guepinia Spathularia*, 17  
*Guignardia pipericola*, 6  
*Gutierrezia glomerella*, 205  
*Gymnopogon foliosus*, 259  
*Gymnosporangium Betheli*, 207; *clavariaeforme*, 206; *corniculans*, 84; *gracilens*, 202; *inconspicuum*, 206; *juvenescens*, 84, 86, 207; *Nelsoni*, 202  
*Halerpestes Cymbalaria*, 79  
*Hapalopilus gilvus*, 128; *lichnoides*, 15, 128  
*Helotium Cecropiae*, 50; *phlebo-phorum*, 50  
*Helvella infula*, 110, 112  
*Helvellaceae*, Un nuevo genero de las, C. Spegazzini, 210  
 Heteroecious rusts in 1922, 1923 and 1924, Culture experiments with, W. P. Fraser, 78  
*Hiattula discreta*, 15  
*Hicoria*, 99, 197; *alba*, 76  
*Hieracium*, 150  
*Hordeum jubatum*, 78, 81, 82  
*Hormodendron*, 90

- Humaria, 157; *Cookeina*, 46; *leucoloma*, 46; *phyllogena*, 46  
*Hutchinsia procumbens*, 204  
*Hydnocystis*, 253  
*Hydnotrya*, 253  
*Hydnotryopsis*, 254  
*Hydnum beneolens*, 72; *septentrionale*, 72  
*Hydrangea arborescens*, 246  
*Hydrogera crystallina*, 2  
*Hygrophila brasiliensis*, 139  
*Hygrophorus*, 113, 117  
*Hypocrea rufa*, 5, 90  
*Hypomyces*, 184  
*Hypospila cordiana*, 6  
*Hypoxyton*, 187, 220; *annulatum*, 7; *effusum*, 7; *fuscopurpureum*, 7; *fuscum*, 7; *jecorinum*, 7; *pruinatum*, 218; *pseudopachyloma*, 7; *rubiginosum*, 7  
*Hypoxyton poplar canker in Oxford County, Maine, Preliminary survey of*, E. J. Schreiner, 218  
*Hyptis atrorubens*, 140; *capitata*, 140; *lantanifolia*, 140  
*Hysterium rufulum*, 4  
*Hysterographium Pithecellobii*, 49  
*Hystrix patula*, 78, 79, 81, 82, 85  
  
*Ilex*, 197  
Illinois—II, Notes on the parasitic fungi of, L. R. Tehon and Eva Daniels, 240  
Infection of sorghums by loose kernel smut, Modes of, James A. Faris and George M. Reed, 51  
Inheritance of resistance of oat hybrids to loose smut, The, George M. Reed, 163  
*Inga*, 257; *Inga*, 138; *laurina*, 49, 138  
*Inonotus hirsutus*, 128  
*Ionomidotis portoricensis*, 50  
*Ionopsis utricularioides*, 138  
*Ipomoea coccinea*, 10; *glabra*, 255; *Nil*, 10; *Pes-caprae*, 3; *triloba*, 11  
*Irene albionensis*, 140; *calostroma*, 143; *cyclopoda*, 140, 147; *glabra*, 139; *glabroides*, 142; *hyptidicola*, 139; *irregularis*, 139; *Laguncularia*, 141; *longipoda*, 141; *manca*, 143; *Melastomacearum*, 141, 145, 147; *Perseae*, 140; *portoricensis*, 141; *Puiggarii*, 143; *sepulta*, 139; *triloba*, 142  
*Iresine elatior*, 12  
  
*Jatropha gossypifolia*, 13  
Jenkins, Anna E., Brown canker of roses, 87  
*Juglans*, 98  
*Juncus*, 109  
  
*Juniperus monosperma*, 74; *scopulorum*, 202, 207; *siberica*, 206  
  
Kauffman, C. H. The genus *Gomphidius* in the United States, 113  
*Koeleria cristata*, 42, 82; *gracilis*, 81  
*Kuehneola*, 256  
  
*Lachnea*, 157; *coprinaria*, 47; *scutellata*, 4  
*Lactaria lactaria*, 128; *lactiflua*, 183; *piperata*, 183  
*Lactuca canadensis*, 150, 152; *virosa*, 152  
*Laguncularia*, 98; *racemosa*, 141  
*Lamprospora*, 222, 224; *areolata* var. *australis*, 223; *discoidea*, 47; *salmonicolor*, 47; *tuberculata*, 223; *Wrightii*, 47  
*Larix occidentalis*, 68, 69  
*Lasiacis sorghoidea*, 258  
*Lasiobolus*, 157  
*Lathyrus utahensis*, 205  
*Lentinus dentatus*, 77; *hirtus*, 15; *lepideus*, 90; *velutinus*, 77; *xylopodius*, 16  
*Lenzites*, 117  
*Leonotis nepetaefolia*, 12  
*Lepargyrea*, 79; *argentea*, 80, 82, 83; *canadensis*, 80-82, 85  
*Lepidium simile*, 204  
*Leptothyrium maximum*, 245  
*Lichen atratus*, 4  
Life cycle of the rust on fly poison, *Chrosperma muscaetoxicum*, The, C. R. Orton and Freeman Weiss, 148  
Life history and relationships of *Diplodia gossypina*, The, Neil E. Stevens, 191  
*Liquidambar*, 98, 99, 197  
*Liriodendron*, 72, 98, 99, 107  
*Lisea australis*, 5  
Lister's "Mycetozoa," Miss, 265  
*Lolium multiflorum*, 81; *perenne*, 81  
Loose kernel smut, Modes of infection of sorghums by, James A. Faris and George M. Reed, 51  
*Lucuma*, 99  
*Lupinus*, 205, 208  
*Lychnis alba*, 53, 64  
*Lycoperdon Zeae*, 13  
*Lycopus asper*, 83, 86  
*Lygodium*, 255  
  
*Macrophoma*, 197; *arens*, 42  
*Madia*, 227; *citriodora*, 229; *exigua*, 229; *glomerata*, 229; *Nuttallii*, 228; *racemosa*, 229; *ramosa*, 229; *sativa*, 229

- Maine, Schreiner, E. J., Preliminary survey of Hypoxylon poplar canker in Oxford County, 218
- Magnolia, 99
- Marasmius arecarius, 15
- Maraschia alba, 257; *Ingae*, 257; pallida, 257
- Maytenus elongata, 138, 147
- Melampsora albertensis, 206; Bigelowii, 203; confluens, 202
- Melampsorella elatina, 203; Cerastii, 203
- Melampsoropsis Pyrolae, 84, 86
- Melanops Quercuum, 192, 201, 203; Quercum forma Vitis, 192, 201
- Melanthera, 257
- Melia, 99, 107, 143
- Melilotus alba, 39;
- Meliola, 145, 146; aibonitensis, 140; arecibensis, 144; Calophylli, 144; calostroma, 143; compositarum, 144; cyclopoda, 140; glabra, 139; glabroides, 142; hyptidicola, 139; irregularis, 139; Lagunculariae, 141; longipoda, 141; manca, 142, 143; Melastomacearum, 141; Persea, 140; Persea forma setulifera, 140; Puiggarii, 142, 143; rubicola, 143; sanguinea, 142, 143; sepulta, 139; triloba, 142; tuberculata, 144
- Mentha, 83; canadensis, 247
- Merulius, 108; armeniacus, 72; aureus, 72; interruptus, 72; rufus, 72; rugulosus, 112; Spathularia, 17
- Metastelma Schlechtendalii, 11, 12
- Miconia laevigata, 142; prasina, 142
- Microcera coccophila, 127
- Micropeltella, 135
- Micropeltis albo-marginata, 135, 139, 147; longispora, 136
- Mikania, 257; cordifolia, 144
- Milesina Lygodii, 255
- Modes of infection of sorghums by loose kernel smut, James A. Faris and George M. Reed, 51
- Mold associated with the ripening of blue veined cheese, The, N. S. Golding, 19
- Mollugo verticillata, 42
- Monochaetia Paeoniae, 244
- Morchella crassipes, 221
- Morenoella Whetzelii, 134, 147
- Morus alba, 105, 106
- Mucor, 90
- Muhlenbergia racemosa, 82
- Murrill, W. A., Botanizing in Virginia, 44; Collecting around St. Augustine, Florida, 127; Fungi at Lynchburg, Virginia, 183
- Mycological foray, Fred J. Seaver, 263
- Mycological notes for 1924, O. L. Overholts, 108
- Mycosphaerella, 111; cornicola, 240; rubina, 37; smilacicola, 111
- Mykoserinx Cissi, 14
- Myriangium Curtisii, 127, Montagnei, 127; tuberculans, 127
- Myrica cerifera, 143, 144
- Nabalus, 149, 151; albus, 150, 152; integrifolius, 152; serpentarius, 150, 152; trifoliolatus, 148-150, 153
- Naucoria pediades, 16
- Nectandra patens, 142
- Nectria episphaeria, 5; vulgaris, 5
- Nepeta cataria, 247
- New or noteworthy Porto Rican pyrenomycetes, Rafael A. Toro, 131
- New species of fungi, G. Bresadola, 68
- Nidularia vernicosa, 17
- Notes for 1923, Mycological, L. O. Overholts, 108
- Notes on the parasitic fungi of Illinois—II, L. R. Tehon and Eva Daniels, 240
- Noteworthy Porto Rican pyrenomycetes, New or, Rafael A. Toro, 131
- Nuevo genero de las Helvellaceas, Un, C. Spegazzini, 210
- Nummularia dura, 7; repanda, 8; tinctor, 8
- Nycteromyces, 87
- Octospora leucoloma, 46
- Odontia eriozona, 71; farinacea, 72; furfurella, 71; stenodon, 71
- Oidium Cyparissiae, 10; erysiphoides, 10; lactis, 90
- Oliganthes condensatus, 259
- Orbilia, 48
- Orton, C. R., and Freeman Weiss, The life cycle of the rust on fly poison, Chrosperma muscaetoxicum, 148
- Ostrya virginica, 105
- Overholts, L. O., Mycological notes for 1923, 108
- Oxford County, Maine, Schreiner, E. J., Preliminary survey of Hypoxylon poplar canker in, 218
- Pachyphloeus, 253, 254
- Paeonia, 248; arborea, 244; officinalis, 244, 247
- Panicum adpersum, 11; barbinode, 13, 258
- Panus xylopodius, 16
- Parasitic fungi of Illinois—II, Notes on the, L. R. Tehon and Eva Daniels, 240
- Parodiella grammodes, 3
- Paspalum conjugatum, 259; fimbriatum, 12; virgatum, 260
- Patellaria atrata, 4

- Paxillus, 116, 117, 121  
 Penicillium, 38, 90, 94; glaucum, 19; roqueforti, 19, 20, 22-32  
 Peniophora, 68; albo-straminea, 69, 70; crenea, 69; gilvidula, 70; lepida, 70; rhodochroa, 70; Weiri, 70  
 Penstemon acuminatus, 84, 86  
 Periconia atra, 10  
 Peridermium Pini acicola, 225; acicolum, 233; californicum, 229, 230, 233; elatinum, 203; montanum, 230, 233; oblongisporium, 225; Weirii, 235  
 Peronoplasmopara cubensis, 3  
 Peronospora cubensis, 3  
 Persea Persea, 140  
 Persicaria Hartwrightii, 208; psycrophila, 208  
 Peziza adnata, 47; badia, 157; coprinaria, 47; dochmia, 48; leucorhodinum, 48; omphalodes, 4, 48; scutellata, 4; vesiculosa, 157, 158; Wrightii, 47  
 Phacidium minutissimum, 240; Negundinis, 240  
 Phaeosaccardinula Seaveriana, 145  
 Phaeoseptoria Caricis, 245  
 Phalaris arundinacea, 81, 82  
 Phellomyces sclerotiphorus, 215  
 Phialea Cecropiae, 50; microspora, 50  
 Phillipsia, 48; Chardoniana, 48  
 Phlebia radiata, 108  
 Phleum pratense, 203  
 Phlox canescens, 203  
 Pholiota Johnsoniana, 184  
 Phoma, 241; lathyrina, 9  
 Phomopsis Callistephi, 242  
 Phragmidium Montivagum, 203; occidentale, 206  
 Phycomyces, 94, 95; nitens, 89  
 Phyllachora biareolata, 5; Crotonis, 5; graminis, 6; Rickseckeri, 6; sphaerosperma, 6; Whetzelii, 5  
 Phylloporus rhodoxanthus, 117  
 Phyllosticta Allii, 241; Ambrosiae, 42; Aquilegiae, 241; hesperidearum, 241; Pithecolobii, 9; pteleicola, 241  
 Physalis peruviana, 217  
 Physalospora, 6, 193; Andirae, 8; Cydoniae, 197; gossypina, 195, 198, 200, 201; malorum, 98-107, 191-201  
 Physalospora in the eastern United States, Botryosphaeria and, C. L. Shear, Neil E. Stevens and Marguerite S. Wilcox, 98  
 Picea canadensis, 84, 86; Engelmanni, 75; sitchensis, 75  
 Pilea parietaria, 142  
 Pilobolus, 89-91, 93, 94, 96, 157; crystallinus, 2  
 Pinus, 69; Banksiana, 237; contorta, 75, 76, 226, 228, 230, 231, 233-235, 237; edulis, 237; Jeffreyi, 228, 229; monticola, 69, 70; pinea, 237; ponderosa, 70, 228, 237; ponderosa var. scopulorum, 230; radiata, 229, 232, 233; rigida, 232, 233; silvestris, 225, 236, 237; virginiana, 71  
 Piper aduncum, 139; Amalago, 6; Sieberi, 6  
 Pithecellobium glomeratum, 257; latifolium, 257; Unguis-cati, 9, 50  
 Plantago eriopoda, 83, 85  
 Plasmodiophora Brassicae, 160-162  
 Platanus, 99  
 Plowrightia ribesia, 37  
 Pluteus cervinus, 184  
 Poa compressa, 78; pratensis, 78; triflora, 82  
 Pogonomyces hydroides, 16, 128  
 Poinciana, 99  
 Polyandromyces, 87  
 Polygonum bistortoides, 208  
 Polypodium incanum, 128  
 Polyporus Alabamiae, 16; capucinus, 74; Colossus, 16; fomentarius, 15; hirsutus, 14; leucoxanthus, 73; lichnoides, 15; melleo-fulvus, 75; occidentalis, 14; pinsitus, 14; resinus, 18; squamosus, 90; subcapucinus, 74  
 Polystictus elongatus, 73; pallidulus, 73; prolificans, 73  
 Poplar canker in Oxford County, Maine, Preliminary survey of Hypoxylon, E. J. Schreiner, 218  
 Populus tacamahacca, 220; tremula, 73; tremuloides, 206, 218-220; trichocarpa, 69, 76  
 Poria Alabamiae, 16; bombycina, 76; corticola, 76; crustulina, 75; dichroa, 75; fagicola, 75; fulvella, 76; hibernica, 75; levis, 75; luteo-alba, 75; mucida, 76; proxima, 76; radula, 77; similis, 76; subacida, 77; vicina, 76; zonata, 77  
 Poronia Oedipus, 8  
 Porto Rican cup-fungi. Studies in tropical ascomycetes—III, Fred J. Seaver, 45  
 Porto Rican pyrenomycetes, New or noteworthy, Rafael A. Toro, 131  
 Potomorphe peltata, 145  
 Preliminary survey of Hypoxylon poplar canker in Oxford County, Maine, E. J. Schreiner, 218  
 Priva lappulacea, 9  
 Prosopodium appendiculatum, 10  
 Prunus, 99; domestica, 105; virginiana, 105  
 Psalliotia campestris, 90  
 Pseudelephantopus spicatus, 140

- Pseudobalsamia*, 253  
*Pseudomeliola collapsa*, 145  
*Pseudotsuga taxifolia*, 75  
*Psilocybe Antillarum*, 16  
*Ptelea trifoliata*, 241  
*Puccinellia*, 79  
*Puccinia*, 79, 149, 152; *Absinthii*, 203; *Andropogonis*, 84, 86; *angustata*, 83, 84, 86; *antioquiensis*, 258; *Antirrhini*, 42; *appendiculata*, 10; *Archavaletae*, 11, 258; *atropuncta*, 148, 149, 151, 152; *Blechi*, 11; *canaliculata*, 258; *Cannae*, 259; *Caricis-shepherdiae*, 42, 82; *Cenchri*, 11, 259; *Cicutae*, 207; *Clematidis*, 78, 79, 85, 207; *Convolvuli*, 13; *coronata*, 79, 80, 82, 83, 85; *crassipes*, 11; *Crepidia-Montanae*, 209; *Douglasii*, 203; *Eleutherantherae*, 259; *Emiliae*, 11, 259; *epiphylla*, 204; *Eriophori*, 83, 84; *Gouaniae*, 259; *Graminis*, 203; *Grindeliae*, 206; *Grossulariae*, 206; *Gutierreziae*, 206; *Gymnopogonis*, 259; *heterospora*, 11; *hieraciata*, 150-152; *Huberi*, 11; *ignava*, 259; *impedita*, 11; *inflata*, 11; *insueta*, 11; *insulana*, 12; *invaginata*, 12; *Ipomoeae-panduranae*, 11; *Jonesii*, 204; *Leonotidis*, 12; *levis*, 12; *macropoda*, 12; *Melanthii*, 148; *Menthae*, 11; *Mesneriana*, 151; *mutabilis*, 204; *obliqua*, 12; *obliterata*, 206, 207; *Opizii*, 150; *opulenta*, 11; *Osmorrhizae*, 204; *Pimpinellae*, 204; *Poarum*, 204; *Polygoni-Amphibii*, 208; *Polygoni-vivipari*, 208; *Rhamni*, 151; *Seaveriana*, 259; *Sherardiana*, 204; *Spermacoces*, 12; *subnitens*, 83, 85, 204; *Synedrellae*, 9, 12; *tuberculans*, 205; *tubulosa*, 259; *Urbaniana*, 12, 260; *universalis*, 205; *variolans*, 207; *Vernoniae*, 12; *Violae*, 205; *Zygadeni*, 148, 151  
*Pucciniastrium pustulatum*, 205  
*Puccinosira pallidula*, 12  
*Pycnoporus sanguineus*, 16, 128  
*Pyrenium lignorum*, 10  
*Pyrenomyces*, New or noteworthy  
*Porto Rican*, Rafael A. Toro, 131  
*Pyrola asarifolia*, 84, 86  
*Pyronema omphalodes*, 4, 48  
*Pyrus Malus*, 99, 101  
*Pyropolyporus Calkinsii*, 128; *Robiniae*, 183  
*Quamoclit coccinea*, 11  
*Quercus*, 99, 107, 197; *bicolor*, 42  
*Ramularia*, 246; *tenuis*, 42  
*Ranunculus acris*, 79; *recurvatus*, 42; *septentrionalis*, 42  
Reed, George M., The inheritance of resistance of oat hybrids to loose smut, 163  
Reed, George M., and James A. Faris, Modes of infection of sorghums by loose kernel smut, 51  
Relation of glycogen to spore-ejection, Leva B. Walker and Emma N. Andersen, 154  
Relationships of *Diplodia gossypina*, The life history and, Neil E. Stevens, 191  
Resistance of oat hybrids to loose smut, The inheritance of, George M. Reed, 163  
*Rhamnus*, 79, 151; *alnifolia*, 80, 82, 85; *cathartica*, 80, 82, 85  
*Rheum officinale*, 248; *Rhaponticum*, 248  
*Ribes*, 99, 101, 227; *aureum*, 202, 207; *cereum*, 206, 237; *inebrians*, 206, 237; *inermis*, 237; *leptanthum*, 237; *longiflorum*, 237  
*Ricinus*, 99  
Ripening of blue veined cheese, The mold associated with the, N. S. Golding, 19  
*Robinia pseudacacia*, 73  
*Rosa*, 99; *neomexicana*, 203; *pyrifera*, 203  
*Rosellinia*, 185, 186; *aquila*, 8; *Bambusae*, 187, 189; *Bresadolae*, 8; *geasteroides*, 187, 188; *metachroa*, 8; *St. Cruciana*, 8; *subiculata*, 8  
Roses, Brown canker of, Anna E. Jenkins, 87  
*Rostkovites granulatus*, 44  
*Rubus*, 35, 39, 99, 143  
*Rubus allegheniensis*, 42; *occidentalis*, 33, 42; *parviflorus*, 206; *strigosus*, 33, 40  
*Rumex pauciflorus*, 208  
*Russula*, 128; *compacta*, 183; *foetens*, 183; *Mariae*, 183; *nigricans*, 184; *virescens*, 183  
Rust, The snapdragon, Fred J. Seaver, 42  
Rusts of British Guiana and Trinidad, H. Sydow, 255  
Rusts of Utah—V. Smuts and, A. O. Garrett, 202  
*Sabina horizontalis*, 84, 86  
*Saccharum officinarum*, 10  
*Salix*, 70, 99, 107; *lasiodora*, 71; *Scouleriana*, 202; *subcoerulea*, 203  
St. Croix, The fungous flora of, Fred J. Seaver, 1  
*Salvia occidentalis*, 11  
*Sambucus*, 99; *canadensis*, 105

- Saponaria, 183  
 Sarcoscypha coccinea, 157  
 Sassafras, 99  
 Sauvagesia erecta, 142  
 Schizachyrium scoparium, 84, 86  
 Schizophyllum alneum, 16  
 Schizostachyum, 189  
 Schoenocaulon dubium, 148  
 Schreiner, E. J., Preliminary survey of Hypoxylon poplar canker in Oxford County, Maine, 218  
 Scleria melaleuca, 258  
 Scleroderma, 128  
 Sclerotin a fructigena, 90, 96  
 Scolecopeltis, 135; aeruginea, 146; Cestri, 137; Chardonii, 128; Ingae, 138, 147; Ionopsidis, 137; longisporea, 136; micropeltiformis, 137, 147; pachyasca, 136; portoricensis, 137; transiens, 147  
 Scolecopeltopsis, 135  
 Scolochloa festucacea, 80-83  
 Seaver, Fred J., Discomycetes of Australia, 222; Mycological foray, 263; Studies in tropical ascomycetes—III. Porto Rican cup-fungi, 45; The fungous flora of St. Croix, 1; The snapdragon rust, 42  
 Secale montanum, 52, 64  
 Securidaca volubilis, 134  
 Senecio, 227; aureus, 84; canus, 83; hydrophiloides, 236; triangularis, 234, 235  
 Septogloeum querceum, 42; subnudum, 42  
 Septoria canadensis, 245; cenchrina, 42; cornicola, 244; Corni-maritis, 245; Floridae, 244  
 Shear, C. L., Neil E. Stevens and Marguerite S. Wilcox, Botryosphaeria and Physalospora in the eastern United States, 98  
 Sida carpinifolia, 133; supina glabra, 11  
 Smilacina racemosa, 246  
 Smilax, 111; herbacea, 42; rotundifolia, 111  
 Smuts and rusts of Utah—V, A. O. Garrett, 202  
 Snapdragon rust, The, Fred J. Seaver, 42  
 Solanum, 134; tuberosum, 216  
 Solidago, 227, 230; canadensis, 232, 233; latifolia, 42; missouriensis, 234; oreophila, 234; rugosa, 233  
 Sonchus, 227; arvensis, 236; asper, 236, 237; oleraceus, 236  
 Sophia intermedia, 204  
 Sorghum, 66; saccharatum, 66  
 Sorosporium Reilianum, 51  
 Species of fungi, New, G. Bresadola, 68  
 Spegazzini, C., Un nuevo genero de las Helvellaceas, 210  
 Spermacoe, 12  
 Sphacelotheca cruenta, 51, 53, 54-60, 64-67; Sorghi, 51, 56-58, 66  
 Sphaeralcea coccinea, 204  
 Sphaerella smilacicola, 111  
 Sphaeria annulata, 7; aquila, 8; calostroma, 142, 143; concentrica, 6; Dematium minor, 216; episphaeria, 5; Eschscholzii, 6; Filum, 9; fimi-cola, 5; fusca, 7; fusco-purpurea, 7; graminis, 6; grammodes, 3; ochroleuca, 5; Quercuum, 193, 200; repanda, 8; rubiginosa, 7; rufa, 5; smilacicola, 111; subiculata, 8; tinctor, 8  
 Sphaerobolus, 154, 157-159; stellatus, 155  
 Sphaeromeria diversifolia, 203  
 Sphaeronema acerinum, 112  
 Sphaeropsis, 99, 107, 196; acerina, 243; grandinea, 243; malorum, 100, 102, 105, 106, 192, 201; Negundinis, 242; simillima, 243  
 Sphaerosoma alveolatum, 223; echinulatum, 223  
 Sphenopholis obtusata, 82  
 Spirogramma Boergesenii, 8  
 Spondyliocladium atrovirens, 217  
 Spore-ejection, Relation of glycogen to, Leva B. Walker and Emma N. Andersen, 154  
 Sporobolus cryptandrus, 81; indicus, 262  
 Stachytarpheta, 260  
 Stagonospora albens, 42  
 Stenanthium gramineum, 152  
 Stephensia, 253, 254  
 Stereum, 128; papyrinum, 16  
 Stevens, Neil E., The life history and relationships of Diplodia gossypina, 191  
 Stevens, Neil E., and Marguerite S. Wilcox, C. L. Shear, Botryosphaeria and Physalospora in the eastern United States, 98  
 Stichopsora Madiae, 228  
 Stigmatophyllum periplocifolium, 11  
 Stipa viridula, 81  
 Strobilomyces strobilaceus, 184  
 Studies in tropical ascomycetes—III. Porto Rican cup fungi, Fred J. Seaver, 45  
 Survey of Hypoxylon poplar canker in Oxford County, Maine, Preliminary, E. J. Schreiner, 218  
 Sydow, H., Rusts of British Guiana and Trinidad, 255  
 Synchytrium cinnamomeum, 42; decipiens, 2; nigrescens, 42  
 Synedrella nodiflora, 12

- Tecoma radicans*, 184; Stans, 10  
 Tehon, L. R., and Eva Daniels,  
 Notes on the parasitic fungi of  
 Illinois—II, 240  
*Tetradychia Nuttallii*, 207  
*Thalictrum*, 79  
*Thuja plicata*, 69  
*Tilletia foetens*, 202; *laevis*, 51;  
*Tritici*, 51  
*Tomophagus Colossus*, 2, 16  
 Toro, Rafael A., New or noteworthy  
 Porto Rican pyrenomycetes, 131  
*Torresia odorata*, 81–83  
*Trabutiella*, 7; *Cordia*, 6  
*Trametes*, 75; *cerina*, 74; *elegans*, 15;  
*lignea*, 17; *micans*, 74; *ochroflava*,  
 74; *rigida*, 14; *robiniofila*, 183;  
*rubricosa*, 74; *scleromyces*, 74;  
*subcervina*, 74  
*Tremella glandulosa*, 18  
*Trenomyces*, 87  
*Trichoderma lignorum*, 10  
*Tricholoma rutilans*, 128  
*Trichothyrium collapsum*, 145; *dubio-*  
*sum*, 145, 147  
*Trifolium pratense*, 208  
*Trisetum*, 80  
*Triticum aestivum*, 78; *vulgare*, 202  
*Triumfetta*, 13  
 Tropical ascomycetes—III, Studies  
 in, Porto Rican cup fungi, Fred J.  
 Seaver, 45  
*Tryblidium rufulum*, 3  
*Tsuga heterophylla*, 75  
*Tuber bisporum*, 251; *Gardnerii*, 251;  
*gibbosum*, 250, 251; *giganteum*,  
 250; *irradians*, 252; *longisporum*,  
 251  
*Tuberculina argillacea*, 42  
*Tyromyces semipileatus*, 184  
*Ulmus*, 109; *americana*, 106  
*Uredo Artocarpi*, 262; *Bliti*, 2; *Cissi*,  
 14; *Commelinaceae*, 13; *Cyrtop-*  
*podii*, 262; *Dioscoreae*, 262; *Ele-*  
*phantopodis*, 10; *Erythroxylonis*,  
 13; *Gouaniae*, 12; *ignobilis*, 262;  
*Ipomoeae*, 10; *jatrophiicola*, 13;  
*Jonesii*, 237; *Leonotidis*, 12; *pas-*  
*palicola*, 259; *ribicola*, 237; *Scho-*  
*enocauli*, 148  
*Urocystis occulta*, 51, 52, 64; *Tritici*, 51  
*Uromyces*, 152; *albescens*, 257; *Alope-*  
*curi*, 79; *Anthacanthi*, 13; *colum-*  
*bianus*, 257; *Commelinae*, 13;  
*Dolicholi*, 13, 257; *Eriogoni*, 205;  
*Euphorbiae*, 13; *Fabae*, 205; *fal-*  
*lens*, 208; *gemmatus*, 13; *hetero-*  
*dermus*, 205; *intricatus*, 205; *lepto-*  
*dermus*, 13, 258; *occidentalis*, 205,  
 209; *proeminens*, 258; *Rickerianus*,  
 208; *Scleriae*, 258; *Shearianus*, 208;  
*Sidae*, 11; *Silenes*, 208; *substriatus*,  
 208; *Wulffiae-stenoglossae*, 258;  
*Zygadeni*, 151  
*Ustilago Avenae*, 51–53, 66, 163, 164,  
 166, 167, 170, 172–175, 180; *Hordei*,  
 51, 52; *levis*, 51, 52, 163, 164; *nuda*,  
 52; *Tritici*, 52; *violacea*, 53, 64;  
*Zaeae*, 13, 52  
 Utah—V, Smuts and rusts of, A. O.  
 Garrett, 202  
*Vaginata parviflora*, 183; *vaginata*,  
 184  
*Valerianodes*, 12; *cayennensis*, 142  
*Valsa chlorina*, 9  
*Varronia corymbosa*, 141  
*Venenarius Frostianus*, 184; *phal-*  
*loides*, 128, 183, 184; *solitarius*, 183,  
 184  
*Venturia inaequalis*, 37  
*Veratrum parviflorum*, 148; *viride*,  
 152; *Woodii*, 148  
*Vermicularia atramentaria*, 213, 215;  
*Dematium*, 213–216; *maculans*,  
 213–215; *minuta*, 213, 216; *ortho-*  
*spora*, 213, 216; *varians*, 217  
*Vermicularia*, *Colletotrichum* v., B.  
 T. Dickson, 213  
*Vernonia albicaulis*, 12  
*Verticillium albo-atrum*, 94  
*Viburnum*, 99  
*Viola*, 244; *adunca*, 205; *scabriuscula*,  
 42  
 Virginia, Botanizing in, W. A.  
 Murrill, 44  
 Virginia, Fungi at Lynchburg, W. A.  
 Murrill, 183  
*Vitis*, 99, 197  
*Volutella circinans*, 214  
 Walker, Leva B., and Emma N.  
 Andersen, Relation of glycogen to  
 spore-ejection, 154  
*Wedelia buphthalmoides*, 9  
 Weir, James Robert, The genus  
*Coleosporium*, 225  
 Weiss, Freeman, C. R. Orton and,  
 The life cycle of the rust on fly  
 poison, *Chrosperma muscaetoxi-*  
*cum*, 148  
 Wilcox, Marguerite S., C. L. Shear,  
 Neil E. Stevens and, *Botryo-*  
*sphaeria* and *Physalospora* in the  
 eastern United States, 98  
*Wulffia baccata*, 258  
*Xylaria apiculata*, 9; *appendiculata*,  
 9; *lignosa*, 9  
 Zea Mays, 13, 248  
 Zeller, S. M., *Coryneum Ruborum*  
 Oud. and its ascogenous stage, 33  
*Zygadenus*, 151; *elegans*, 148  
 Zonation in cultures of *Fusarium dis-*  
*color sulphureum*, G. R. Bisby, 89







